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HARRY AND LUCY

CONCLUDED.



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HARRY AND LUCY

CONCLUDED.

OUR travellers next arrived at Frankland Hall, in Staffordshire, where they were to spend three days, with their friends, Mr. and Mrs. Frankland.

The first day at dinner, an old gentleman observed, that the pie dishes of Wedgwood's ware were good contrivances for keeping vegetables hot, and remarked, how very like real pie-crust one of them looked.

Mr. Frankland, who had been an intimate friend of the late Mr. Wedgwood, said that he was present the first day when one of these imitations of pie-crust appeared at dinner: the children of the family did not mistake it for a real pie, and Mr. Wedg-

wood had new ones made repeatedly, till at last one appeared so perfect, that at a little distance it could not be known from pie-crust. "When I took off the cover," said Mr. Frankland, "the child next me was agreeably surprised to hear it jingle on the dish."

"Besides this," said the old gentleman, "Mr. Wedgwood made a number of little every-day useful contrivances; that dish, in which there is a well for the gravy. In the olden times, unhappy carvers were obliged to poke under the heavy sirloin for gravy; or to raise and slope the dish, at the imminent hazard of overturning the sirloin, and splashing the spectators. Knife, fork, spoon, slipping all the while, one after another, into the dish! And, ten to one, no gravy to be had after all! Nothing but cakes of cold grease. But now, without poking, sloping, splashing, the happy carver, free from these miseries of life, has only to dip his spoon into a well of pure gravy. Thanks to the invention

of one man, all men, women, and children, may now have gravy without stooping the dish. So I give you, gentlemen and ladies, for a toast, 'The late Mr. Wedgwood, and the comforts of life.'"

After he had drank his glass of wine, the old gentleman continued speaking:—

"I remember that Mr. Coxe, the traveller, was pleased by meeting with a beautiful service of Wedgwood ware in Russia. I dare say he might find one now in Siberia. Last year, when I was in Holland, I learnt, that even the town of Delft, which, for many years, used to furnish all Europe with crockery, is now supplied from England with our Staffordshire ware."

The conversation next turned on China, and Chinese artists.

"They are very exact," said Mr. Frankland, "in imitating whatever is bespoken from them, but sometimes they carry this to a degree of provoking stupidity."

Of this he gave an instance. A lady wanted to match some of the plates of a

remarkably handsome service of china, which had been given to her husband by the East India Company. She sent a pattern to China, and bespoke some dozens to be made exactly the same. In due time they arrived, were unpacked, but, to her surprise and mortification, the lady found, that every one of the new plates had the appearance of a crack across it; and, on examining the plate which had been sent as a pattern, it was found that there was a crack in it, which had been exactly imitated.

Even Harry, though he loved exactness, thought this was too much.

Lucy observed the beauty of the china, On her plate there lay, or there seemed to lie, a convolvulus: it looked so natural, that she thought she could take it up. On her mother's was a Celsia, a geranium on another, and on Harry's a honeysuckle, of which she could almost fancy that she smelt the perfume. Even as she eat her ripe cherries, she paused to examine these

flowers. She thought it the most beautiful china she had ever seen. When she went into the drawing-room she saw on the chimney-piece flower-pots of the most delicate blue, with white figures on them, embossed like ivory, and exquisitely carved. The drapery on the figures was so light, that it seemed as if blown by the wind, and so transparent, that she could see the blue ground through it.

Mrs. Frankland came to Lucy, as she was looking at these flower-pots, and told her that they were Wedgwood's ware, as well as the plates which she had admired at the dessert.

"Wedgwood's ware!" repeated Lucy. "I thought that Wedgwood's ware was always black or cream-coloured, such as the common yellowish plates."

Mrs. Frankland told her there was a great variety of Wedgwood's wares. She took her into a cabinet at the end of the drawing-room, where she showed her several vases, made in imitation of antiques, which

had been dug up from the ruins of Etruria, in Italy, and thence called Etruscan. Some had red grounds, with black figures ; others red figures, on black grounds ; others, which were called jasper, were very valuable. After Lucy had examined and admired all these, Mrs. Frankland said she would show her another, which was more valuable than all the rest. The original, from which it was exquisitely imitated, cost the present possessor four thousand guineas. As she spoke she opened the case which contained the vase, and carefully raised it from its crimson-cushioned bed.

“ I know it, I have seen it before, mamma,” exclaimed Lucy.

“ Seen it before, Lucy !” said her mother. “ Where ?”

“ In a book, when I was reading to you, mamma.”

“ You mean, that you have seen an engraving of it,” said her mother.

“ Yes, mamma, you remember the three views in the Botanic Garden, of a vase just

like this, with a dark ground and white figures. I cannot recollect the name of it, but I know it was dug up out of ruins."

Her mother told her it was called the Barberini, or Portland vase. *Barberini* from the name of the Italian family to whom it had belonged; and *Portland* from the Duchess of Portland, by whom it had been purchased and brought to England.

Lucy, whose memory was now awakened, recollected Dr. Darwin's beautiful lines addressed to Mr. Wedgwood, "Oh friend of art!" but she refrained from repeating them, for which Harry gave her credit due.

Mr. Frankland, who now came into the room, told her, that the ancient Etruscan, or Greek vases, were produced by a different process from that which Mr. Wedgwood used in making his. They appear to have been made by covering the parts representing the figures and ornaments, after their outlines had been traced, and then dipping the red ware in a black paint.

The lines of the drapery, &c. were afterwards traced in the same colour. In those ancient vases, the colour, which was red, was in the *body* of the ware itself. In Mr. Wedgwood's imitations, both the red and black are painted *on* the porcelain, or rather on the *biscuit*; the name which is given to the ware after its first baking in the furnace. He was the first person who made what are called dry colours, or enamel, without lustre, without shining.

Harry thought that the smoothness and polish of these vases was more beautiful than any glazing.

"And much safer, and more durable," said Mr. Frankland. "These colours cannot be injured by damp, or fire, or air, or acid, and will last as long as the substance itself. You may have observed, that the glazing on common earthenware runs into little cracks."

"Yes," said Lucy, "I have often observed them covering a plate, like network. They look very ugly."

"But what is much worse," continued he, "in most kinds of glazing, lead is employed, which, when dissolved in certain acids, is poisonous.

Lucy observed, that *glazing* looked something like *glass*, and from the sound of the words too, she believed *glazing* came from *glass*. It might at first have been called glassing."

"Yes," said Mr. Frankland, "and there is, as you observe, a resemblance between the outside of some porcelain and glass. But the difference between glass and porcelain is, that porcelain is but *semivitrified*, that means half turned to glass. The managing the heat so as to stop the vitrification, or turning to glass, at the right time, is one of the most important points in making porcelain."

Lucy returned to admire the beauty of the Wedgwood's ware, repeating, that she thought it much prettier than Chinese china.

“ Besides the beauty of form, and colour, and texture,” continued Mr. Frankland, “ the utility is great. It is not only perfectly safe for all culinary purposes, but most durable for some chemical experiments, in which the vessels must be exposed to great heat.”

Mr. Frankland showed them a crucible and a retort, made of Wedgwood’s ware, and Mrs. Frankland showed a white pestle and mortar, which looked like marble, but which was of Wedgwood’s ware, and used for pounding medicines.

Harry asked whether the potteries, where all these were made, was near Frankland Hall.

“ Yes, within a few miles of us,” said Mr. Frankland, “ at a village to which Mr. Wedgwood gave the name of Etruria, and where he established a manufactory, whose productions are probably more known, and more useful to a greater number of people, than ever were those of the ancient Etruria.”

Mr. Frankland said, that he would the

next day take Harry and Lucy to see these works. In the mean time, as Harry seemed anxious to know more, he told him all that he thought could interest him, concerning the history of the Staffordshire potteries. The clay of this part of England being fit for making some kinds of earthen ware, there have been potteries, or remains of potteries, in Staffordshire, ever since the time when the Romans were in Britain ; but they had continued in a rude state for ages, as no person of industry or knowledge had attempted their improvement, till, about a hundred and twenty years ago, when two brothers of the name of Elers came from Holland, settled here, and manufactured a red unglazed porcelain. Afterwards they made a sort of brown glazed stone ware, coarse and heavy, yet the glazing of these, such as it was, could not be performed without great inconvenience. They used muriate of soda, which they threw into the oven at a certain time of the baking of the vessels. The fumes

from this were so odious, that the neighbourhood were alarmed, and forced the strangers to abandon their potteries, and quit the country. Soon afterwards, a workman, who had found out the secret of their mode of glazing, for even that was a secret, pursued the same method in a pottery of his own ; and this was suffered to go on in spite of the nauseous fumes, because the inhabitants found the jars they made so useful for holding their butter. They were employed chiefly for this purpose, and the manufactory was called the Butter Pottery. On glazing days, however, the nuisance was terrible, the offensive fumes spread to a distance of six or seven miles. Thick clouds from these furnaces rose over the hills, and filled the valleys with their dense vapours.

The first great improvement in our potteries was made in the substance of the ware itself, by introducing ground flints into the composition, and then was made what is still called white stone ware. It is used

for many purposes. You may have seen it, for instance, for Seltzer water bottles.

"I know what you mean," said Lucy.

"This was the safest and best ware we had," continued Mr. Frankland, "before Mr. Wedgwood's time. It is said, that the first idea of using powdered flints was suggested to a poor Staffordshire potter, by accident."

"By accident! I am glad of it," said Lucy. "I like to hear of discoveries made by accident, especially by poor people."

"There was a Staffordshire potter, whose name is forgotten, or whose name I forget, he stopped on a journey to London, at Dunstable, in Bedfordshire, where the soil is flinty and chalky. He consulted the hostler of the inn where he stopped, about some disorder in his horse's eye. The hostler advised that powdered flint should be put into the eye; and for this purpose he threw a flint into the fire to *calcine*, that is to burn it, that it might be

more easily pulverized. The potter, who was standing by, observed the great whiteness of the calcined flint, and being an ingenious, as well as an observing man, immediately thought of applying this circumstance to the improvement of his pottery. He first tried the experiment of mixing finely-powdered flints with tobacco pipe clay; he succeeded to his hopes, and made white stone ware, which put all the brown and coloured stone ware out of fashion. Ugly as you think it, Lucy, it was much approved, till Wedgwood came, and gave us something better — that cream-coloured ware, which was called queen's ware, because it was first patronized by Queen Charlotte. It was then, and not many years ago, prized in palaces; now it is used in every cottage, and known in every place where plates or dishes are to be found. After this queen's ware, he invented all the varieties which you have seen, and many more."

Mrs. Frankland rang the bell, and or--

dered the servant to bring a plate of cream-coloured Wedgwood ware, another of the white stone ware, a crock of the dark glazed kind, and a common red garden pot; these she placed in the order in which they had been made, beside Wedgwood's beautiful vases, to show Harry and Lucy the difference and contrast.

"And all these improvements, or at least the greatest part of them, were made by one man," thought Harry. "Then more was done by him during his life time than had been done in hundreds of years before."

Lucy asked, if any lucky accidents had happened to Mr. Wedgwood? which put improvements into his head, or gave him the first idea of any of his inventions. She said she should like very much to know the story of these, if Mr. Frankland would tell it to her.

Mr. Frankland said, he did not know of any such, and observed, that though one or two fortunate accidents might occur to

the same person, it was not possible that such progressive improvements, as Mr. Wedgwood had made, could have been suggested by accident, or accomplished by any one who had not scientific knowledge.

"I should like very much," said Harry, "to know what he did first, and what he did next, and how he went on from one experiment to another."

"Of all this, I cannot pretend to give you a history," said Mr. Frankland; "for I am not sure that I know it clearly myself. All I can tell you is, that he improved the potteries by the introduction of substances, which had not before been employed in the composition of these wares. It had been found, that some Cornwall granite is as good for making porcelain of a certain kind, as the clay which the Chinese use. Mr. Wedgwood introduced Dorsetshire and Cornwall clays."

"Perhaps you could tell me, sir," said Lucy, "how the delicate blue of the ground of this flower-pot is made."

“That is given by a substance called cobalt,” said Mr. Frankland. “But as you have never seen it, the word cobalt teaches you little.”

“I wish I knew,” said Lucy, “how the beautiful colours of the flowers on the dessert plates, and how the purple and rose colours on this cup are produced.”

“The purple and rose colours are given by the precipitate of gold dissolved in nitro-muriatic acid: the oxides of iron also produce many of the colours which you admired. But as you are not acquainted with any of the oxides of iron, or with nitric or muriatic acid, or with the precipitate of gold, you know nothing more from my answer than a number of names, which probably you will not be able to remember an hour, and which, unless you learn their properties, could be of no use to you, even if you could keep them in your head all your life.”

“But without telling us all those hard names, sir,” said Lucy, “could not you

give us some general idea of how he did it all?"

Mr. Frankland smiled, and answered, that he did not exactly know what she meant by a general idea of it all. He could tell her only, that Mr. Wedgwood in the first place learnt the properties of different clays and minerals, and what effect would be produced on these by fire. In short, he applied to the study of chemistry and mineralogy, to learn all the experiments which had been made by others, and then he tried new ones for himself; but if he had not read and acquired this knowledge first, he might have wasted his time and ingenuity in doing what others had done before him. Besides genius to invent new and elegant things, he had the good sense to observe what is wanted every day, by the greatest number of people; so that he not only produced what pleased persons of taste, but what was useful to all classes; and he continually considered how he could improve, not only what

others made, but what he had himself produced. It was by this attention to little, as well as to great objects, and by steadily adhering to one course of pursuits, that he succeeded in accomplishing all that he began: no small praise for a man who undertook so much. "The consequences of his success we all know," continued Mr. Frankland, turning to Harry's father, "and we all rejoice in them. Wedgwood made a large fortune for himself and his children, with a character, a reputation, above all fortune. He increased amazingly the industry, wealth, and comforts, of the poor in his neighbourhood; multiplied the conveniencies, elegancies, and luxuries of life for the rich; raised, at home and abroad, the fame of the arts and manufactures of his own country; extended her commerce, and spread his own name with his productions, to the most remote regions of the civilized world."

A pause ensued after these words: all looked with admiration at his works, and those who had known him intimately

sighed for the loss of an excellent man and a kind friend !

The next day, Mr. Frankland took Harry and Lucy to see the works at Etruria. We shall not follow them through all the processes, but shall only mention what Harry and Lucy recollected and told their mother on their return.

“The first thing I remember,” said Harry, “is the improvement in the way of grinding the flints.”

“But you must know, mother, in the first place,” said Lucy, “that formerly this was very unwholesome work, such a quantity of the dust of the powdered flint flew off; and, as the workmen breathed, it went in at their mouths, or up their noses, and it brought on complaints in their lungs and stomachs, and inflamed their eyes besides.”

“All this was remedied,” continued Harry, “by grinding the flints in water, which prevented the dust from flying off. The name of the man who made this improvement, and who made the first mill on

this principle, was Brindley, and the mill is very ingenious."

"But you had better not stop to describe that," said Lucy, "because perhaps mamma does not care as much about it as you do. Now let me go on, Harry, and tell a little. Well, mamma, the flints ground in the great *cauldron*—"

"Mill," said Harry.

"Mixed with water," continued Lucy, "looked at first like chalk and water, thickish; then by mixing with clay, and by stirring, and beating, and straining through sieves, this became first a sort of pulp, and then about as thick as paste or dough, and then it was ready for the man to carry to the potter's-wheel. You know the potter's-wheel, mamma? I remember first seeing the print of it in our book of trades. But there is an improvement in this. The very common one, which I once saw, long ago, was only a circular board turning on a perpendicular stick."

"Axis," said Harry.

"A boy whirled it round for the man, you know, mamma, while he went on

moulding the clay upon it into a bowl, and he called to the boy to make it go slower or faster. But in this potter's-wheel no boy to whirl the board is wanting, for it is turned by a shaft."

"And that shaft is turned by a steam engine," said Harry. "The steam engine, mother, at work again; observe, mother."

"Yes," said Lucy, "papa called it the great servant of all work."

"But there was an improvement in this potter's-wheel, which you have not told yet, Lucy," said Harry.

"No, no, but I am coming to it, let me tell it," said Lucy.

"If you understand it," whispered Harry, in a very kind tone, as he was only afraid for her, not anxious to show what he knew.

"I understand one thing about it, and that is all I want to tell, my dear," said Lucy. "But I will begin another way. You know, mamma, that it is necessary to make the potter's-wheel go slower or quicker, whenever it is desired by the man who is moulding the clay. Formerly this

was done by a boy, who turned it faster or slower as he was bid; but the steam engine, which is now used for keeping this wheel in motion, goes on continually at its own regular rate, and would never mind his calling out 'faster!' 'slower!' 'slower!' 'faster!' Therefore he must have some way of slackening or quickening the wheel, without interfering with the steam engine. This is done for him by the new contrivance, which I will now describe to you, if I can.

"Imagine, mamma, two sugar loaf shaped rollers; two cones of wood standing one with the point down, the other with the point up, and turning on pins run through them, like your silkwinders: these cones are placed at some distance from each other, opposite to the potter's-wheel. Suppose that they are set in motion and kept in motion by the steam engine, and that motion communicated from one of them to the potter's-wheel. Very well. Then next, mamma, imagine a band passed round these two cones, in such a manner that it should always be at

the thicker part of one cone, while it is at the thinner part of the other. Then, when the man wants his great wheel to go faster, he shoves up the band to the thinnest part of the cone which is connected with the wheel, and if he wants it to go slower he pushes the band down to the thicker part; something like the way, mamma, in which, as you may remember, we have seen old Margery with her spinning wheel shift the band from the larger to the smaller rim of her wheel. Harry took notice of the cones as soon as he saw them, and asked what was their use. Papa bid him find out, and he did. Was not that well, mamma?"

"I am glad you remember this, my dear Lucy," said her mother.

"Thank you," said Harry's eyes.

Lucy went on with raised spirits: "Mamma, I wish you had seen the man moulding the clay, and all the metamorphoses of the potter's-wheel. First, in one minute, the lump of clay turned into a bowl; then the instant after, he squeezed this soft bowl up in his hand, dashed it

made in separate moulds, and the halves joined together afterwards. But I dare say, mother, you know all this."

"I knew most of this myself before," continued Lucy, "from the prints and descriptions in our dear book of trades, and from some others of our little and large books. But I liked to see the real work going on, and the real things. There was always some difference between the description and the reality, or something that I fancied larger or smaller than it is, or some little particular circumstance which I did not comprehend till I saw it. Mamma, I did not tell you, that we saw the furnaces and kilns, for baking—*firing* the porcelain, as they call it. These were much larger than I expected. When the porcelain has been once baked, it is called *biscuit*, in which state it is ready for painting. Mamma, I have not told you how much I was entertained in the painting room, by seeing how dull the colours look when they are first laid on, and how bright and brilliant they are after they have been fired —

what was to be gold, was quite dark beforehand."

"Pray, Lucy," said Harry, "did you observe a man, who was standing beside one of the furnaces, whose business seemed to be to regulate the heat? He had some little bits of clay, which looked like little stoppers, and he put these into the fire and measured them, did you see how?"

"No; I saw the man," said Lucy; "but I did not know what he was doing. Well, mamma, there is one other thing I remember, and that is all. You know the common kind of blue and white cups and saucers, and plates, with windmills, and houses, and strange Chinese looking figures, and all manner of things upon them?"

"I do know luckily what you mean," said her mother, laughing, "otherwise I am not sure that I should know it from your description."

"Mamma, these were formerly painted, one at a time, by hand, but now there is a much quicker way; Mr. Frankland showed it to me. First, the patterns, whatever

you wish, houses or churches, or geese or turkies, or shepherdesses, or elephants, or windmills, are printed on paper."

"*Engraved* on copper first," said Harry, "and the blue colour put upon the copper-plate, instead of printer's ink."

"And the blue colour — oh! let me tell that, Harry!" cried Lucy; "the blue colour is made of cobalt."

"*Oxide* of cobalt, I believe," said Harry, "which differs from cobalt, Mr. Frankland told us, if you recollect, Lucy, as much as rust differs from iron."

"Well, oxide of cobalt it should be, I recollect," said Lucy; "and this is mixed with some earth and —"

"And linseed oil," said Harry; "like what is used in printer's ink."

"And when it is altogether about as thick and soft as paste, it is put on the copper-plate. You know, mamma, you showed me common engraving once: and just like any common engraving this is done. As many copies of patterns are taken off on paper as you want.

“ You forgot that the paper was smeared first with soft soap,” said Harry.

“ Then, when you want to use these patterns,” said Lucy, “ the superfluous paper is cut off, and the printed part is moistened and laid on the cup, or whatever you wish to put it on.”

“ The cup must be in the state of biscuit, remember,” said Harry.

“ Biscuit, to be sure,” said Lucy; “ the biscuit instantly sucks in, absorbs the colouring stuff, from the moistened pattern; then the paper is washed off, and you see the coloured pattern printed on the cup directly. Is not that nice and quick, mamma? Then the cup must be let to dry, and afterwards it is dipped in some sort of glazing stuff, and the cobalt, I mean the oxide of cobalt, comes out a beautiful blue. And there is the cup finished, painted in this easy, expeditious way: a hundred thousand, I dare say, could be painted in this manner, while a person could paint one single cup in the old way.”

"The name of the ingenious person, as Mr. Frankland said, who discovered this method of transferring engraving from paper to earthenware, has not been preserved, and I am sorry for it," added Harry.

"Mr. Frankland told us, that since this invention, this blue and white ware has been made in such quantities, and so cheap, that now almost every body can afford to buy it, and it is in every cottage; and the poor people can have now, what only the rich and grand had formerly. Are not you very glad of that, mamma?"

"Yes, I am, my dear," said her mother; "and I am glad," added she, smiling, "that you give yourself time to take breath at last, and that you allow me time to thank you for all you have told me. You seem to have been very much entertained at the potteries, and you have entertained me by your account of them."

"Mamma," said Lucy, "do you think we have remembered enough? I know I cannot recollect half what I saw and heard,

but I remember almost all that I understood clearly."

"That is quite enough, my dear," said her mother; "I never wish you to remember more than you understand. Of what use could it be?"

"Good morning to you, mamma," said Lucy. "I forgot to tell you yesterday, when we were talking about the potteries, that we saw the house, in which Mr. Wedgwood formerly lived; and a very nice house it is."

"Good morning to you, father," said Harry. "Do you recollect yesterday seeing a man standing by one of the furnaces measuring some little stoppers of baked clay, which he slid in between two pieces of brass, like the two parts of a hinged ruler. These pieces of brass were fixed, but not parallel to each other; they were closer together at one end than at the other. The man took the bits of clay, or

stoppers, out of a heated furnace, and he tried each stopper between these rules, and looked at divisions, which were marked on the brass plates. What was he doing, papa?"

"He was using a sort of thermometer, Harry," said his father.

"A thermometer of clay, papa!" said Lucy.

"Yes, for measuring higher degrees of heat than can be shown by that thermometer which you have seen; if that were exposed to heat beyond the highest degree marked on its scale, the quicksilver would expand, so as to burst the glass, and the glass would melt, if put into one of those furnaces which you saw yesterday; but these clay thermometers can bear, and can measure the heat of the fire; for which reason it is called a *pyrometer*, that is, measurer of fire heat."

"I am glad I know the name, and what it means," said Lucy.

"Father," said Harry, "will you be so good as to explain the pyrometer to me?"

"Harry, will you be so good as to use your own understanding?" said his father.

"From what you have seen, and from what I have just told you, you know enough to comprehend or invent the rest, without any further explanation from me."

Harry was silent, and considered first its use. He had seen the man put the stopper into the furnace, and then measure it between the rulers, and afterwards say to another workman — the man who was feeding the furnace, "This heat will do." Now, thought Harry, what change could have been made in the clay, after it had been put into the furnace, and how did he measure it, when he pushed it in between the two rulers? He must have tried whether it had grown larger or smaller, after having been put into the fire.

"I think," said Harry, "that perhaps some sorts of clay either shrink or grow larger, when they are put into the fire. If they did so always regularly, and if people found this, after a number of trials, then they might know the heat of the fire by

the quantity which the clay had shrunk, or increased in size. If this is the case with those bits of clay that I saw, they would be pyrometers, or measurers of fire heat, as you said; I mean if you had the degrees marked upon the ruler to measure them."

"Exactly so," said his father, "you are right, as far as you have gone; still there is a part of the pyrometer which you have not explained to me. You observed that the rulers were not parallel to each other: do you think that was done by accident, or on purpose?"

"I think it must have been on purpose, they seem to have been screwed down on the plate firmly, like a ruler partly open."

"Then, if they were placed so on purpose, for what purpose?" asked his father.

"That the different degrees of shrinking might be measured as the stoppers are pushed in," said Harry. "The person who first made the pyrometer must have tried experiments, and must have marked the different degrees, which the clay shrinks

with different heats. But I do not know by what parts of an inch, or by what scale it is made. The rulers seemed to me to be about two feet long."

"They are," said his father, "and the opening at the widest end is five-tenths, and at the narrowest three-tenths of an inch. And so that this proportion is kept, it does not signify what inches or feet may be used in the length of the rulers. The bits of clay which you saw exactly fit into the widest opening before they have been used, and they shrink according to the degree of heat to which they are exposed, if it is greater than that in which they were first slightly baked."

"Then, papa, they can only show a greater degree of heat, not a lesser, and if they do not swell out again to the former size, they are of no use after they have been in a great heat," said Lucy.

"Of none," replied he, "fresh stoppers must be continually used."

"That is a great inconvenience," said

Lucy, "because you must drag about this weight of stoppers. Not like a nice portable thermometer in its little case."

"But it has so many conveniences, Lucy," said her father, "that we may well pardon that one disadvantage."

"One great convenience I see," said Harry; "the stopper always remains of the same size, after it is taken out of the fire, so that there is no danger of making mistakes about it; you may measure it over and over again: but the quicksilver varies, so that if you do not write down the degree accurately, you are undone."

"This pyrometer," continued his father, "is chiefly used in manufactories, or by chemists, in their laboratories. It has been of great use to Mr. Wedgwood, who made it, from feeling the want of such a measure in his potteries. It was necessary that he should know at what heats certain clays melt or *vitrify*, that is, you know, turn to glass. The common workmen's expressions for this, such as *red heat*, or *white heat*, he found so inaccurate, that, in trying

experiments, many things were spoiled for want of that exact measure which his pyrometer now gives. By it, he has ascertained what heat all kinds of porcelains can bear, without breaking, or melting, or turning to glass. What is of still more use, he can ascertain the exact degree of heat required for baking, or, as they call it, firing any kinds of porcelain or earthenware, of which he could obtain any specimen, whether made in this, or in foreign countries. As Mr. Wedgwood said in describing it, it speaks the language of all nations. The advantage of having an accurate universal measure, in any case, much as it pleases you now, will please you more when your knowledge enlarges, and when you see the further uses to which it can be applied."

"Papa, I remember seeing," said Lucy, "in Scientific Dialogues, the description of a pyrometer, but I do not think that it was made of clay."

"No, that pyrometer is different," said her father; "that measures by the expan-

sion of metal bars with different degrees of heat, which is shown by the motion given to an index."

"Like the hygrometer," said Lucy.

"Yes, and there are several different kinds of pyrometers, of which you can read the description at your leisure," continued her father, "in any encyclopedia, if you have any curiosity about them."

"Yes," said Harry, "I should like to compare them, and see which is best, if I could."

"That would be a good exercise of your judgment, Harry," said his father; "but there are so many they might tire and puzzle you."

"The clay of which Mr. Wedgwood's pyrometers are made," continued his father, "possesses some properties, which fit it peculiarly for the purpose to which it has been judiciously applied. Those half-burnt bits of it, which you saw, Harry, may be dropped at once into intense fire, without cracking; and, when they have re-

ceived its heat, may be plunged into cold water without the least injury. In about three minutes they acquire all the heat from any fire, which they are capable of receiving, so as to contract as much as they ever will from that degree of heat. They may afterwards be left in that heat as long as you please, for they will not change. Take them out, and they can, as you have seen, be cooled in a few seconds, and are then ready for measuring in the gauge, or scale."

"How very convenient!" said Harry. "But as each pyrometer-bit can be used but once, there ought to be a constant fresh supply."

"There are large beds of this clay in Cornwall," said his father; "and to ease your mind, Harry, on this subject, I can tell you, that Mr. Wedgwood offered to give the Royal Society a sufficient space of a bed of that clay, to supply the world with pyrometer pieces for ages."

"I like that very much," cried Lucy.

"I cannot bear, that people who discover scientific things should be covetous of them, or afraid that others should have a share."

"How could you ever think of such a thing?" said Harry.

"I never should have thought of it," said Lucy, "only that I heard a gentleman once at Aunt Pierrepont's say—but I believe I had better not tell it, because it can do no good to any body. But Harry, I hope, and I am sure, that if ever you invent or discover any thing, you will be ready to let others share with you."

"That I will," said Harry; "Oh! I wish it was come to *that*. Father, there is something else I want to say, but I do not know how to express it. It is, that I think, that a person who invents any pyrometer, or hygrometer, or barometer, or new and exact instrument for measuring heat, or cold, or height, or quantity, does more service than a person who invents only a machine, which will do

only for some particular purpose: because those measuring instruments will assist a great many other people in their experiments, for years, perhaps for ages to come. Do you understand what I mean, papa?"

"Yes, my dear, and I think what you say is very true. But do not twist the poor button of my coat any more, or you will pull it off; and let me go now, for there is the breakfast-bell."

"Who will be down stairs first?" cried Lucy, letting go her button, and running foremost. Harry might have overtaken her perhaps, in a race across the hall, but that he stopped to hold open a swing-door for Mrs. Frankland. She had in her hand two small packets, one of which she gave to him, and the other to Lucy. On opening the paper in which these were wrapped, they found two cameos of Wedgwood's ware. Lucy's, which was black on a white ground, represented a negro in chains, kneeling with his hands

raised, in a supplicating manner, with this motto engraved,

“ Am I not a man and a brother ? ”

Harry's cameo was all of one colour, brown. It represented three allegorical figures, Peace, Art, and Labour; and it was made of clay, which had been brought from Botany Bay. Mr. Wedgwood made use of this clay, as Mrs. Frankland told Harry, on purpose to show the settlers and inhabitants of that country, what could be made of their materials by industry and ingenuity; and thus he encouraged them to exert themselves. Of these cameos the late Mr. Wedgwood distributed many hundreds. And no doubt considerable effect was produced by

—— “ the poor fettered slave, on bended knee,
From Britain's sons imploring to be free.”

“ LUCY, you have not seen our garden yet,” said Mrs. Frankland. “ We had not

time yesterday, but if you are fond of a garden come with us now, your mother and I are going there."

"Oh! thank you ma'am," said Lucy; "but I must call Harry, and we will follow you directly."

They followed, and a gay garden it was, full of a variety of bright-coloured flowers, rich beds of carnations, and roses in full blow.

"Roses, moss roses in full blow in September!" cried Lucy. The day before she had left home, she had searched their garden for a rose for her mother, but could find only one poor solitary bud, which had a yellow nightcap on. She asked Mrs. Frankland to tell her how she contrived to make her roses blow so late in autumn.

"By pulling off some of the buds in spring," said Mrs. Frankland, "as soon as they begin to form; and by transplanting some of the rose trees early in the spring, so as to prevent them from

flowering at that time, then they blow in autumn."

Lucy said, she would try this next spring on her own two rose trees.

"Not on both, will you?" said Harry. "Let us pull the buds off one, and leave them on the other, then it will be a fair experiment."

"And besides, you may then have a chance," said Mrs. Frankland, "of the first rose of spring, as well as the last rose of summer."

Lucy took notice of some large clusters of bright blue flowers—agapanthas, and varieties of dahlias: she thought them beautiful, but she supposed that these could not be had without a great deal of trouble and money, and a hot-house, or a gardener at least. But Mrs. Frankland said these did not require a hot-house, or even a gardener's skill. "Indeed," said she, "all the flowers in this garden, excepting perhaps certain carnations, which my gardener prizes highly, though

I do not, may be had by any body with a little care and exertion of their own."

"By any body!" repeated Lucy. "But, ma'am, do you mean bodies like us? like Harry and me? with only our own hands?"

"Yes, bodies like you," said Mrs. Frankland, "with your own hands, provided you use your heads as well as your hands."

"In what way must we use our heads?" said Lucy; "will it be very difficult?"

"No, consult your gardener's dictionary, and follow its directions. Only remember to do so at the right time of year," said Mrs. Frankland. She told Lucy, that she would give her the root of an agapantha, and of some dahlias, and that she and Harry were welcome to seeds, roots, cuttings, or slippings, of any thing they liked in this garden. "Write down what you wish, and I will have them ready by the time your mother brings you here again, as I hope she will on your return homewards."

Joy sparkled in their eyes, and they thanked Mrs. Frankland, with warm gratitude; but, an instant afterwards, they looked unusually grave; for the embarrassment of riches came upon them. They were left to make out their list; and how to choose was the difficulty, where all were beautiful, and when their little garden could not hold all. Harry went to work prudently. He measured out a space of ground, that was the size of their own garden. Lucy could hardly believe that it was so small as what he now showed her; but he had often stepped the boundaries, and was sure of the size of their territories. Rule and measure soon settled the affair, and brought their wishes into proper compass. They calculated what their garden would hold, and made out their list accordingly. Their chief wish was to have a great bed of pinks and carnations.

But the moment they went near these, an old gardener, who was at work in the

garden, and who had long been eyeing them, approached. He began to praise his carnations, which he said were the finest in the county, and he pointed out his favourites. There was the Prince Regent, and the Duke of Wellington, in full glory, these every body knew; but beyond these, he had two superlative new favourites. One he called, *The pride of Holland, or the great Van Tromp*. The other, *The envy of the world, or the great panjandrum*. Harry and Lucy did not much admire either of these. Van Tromp they thought was of a dull colour, and the great panjandrum had burst, and was falling to pieces in spite of his card support. Harry preferred some others.

"That which you are now at, master," said the gardener, "is Davy's Duchess of Devonshire: that little duchess was thought a great deal of some years ago, but she is quite out of fashion now."

Harry did not care for that, he liked her.

"What does he say?" asked the deaf

gardener, turning to Lucy, and leaning down that he might hear the answer.

"I say," cried Harry, speaking loud in his ear, "that I like my little duchess better than your great panjandrum."

"Indeed!" said the gardener, smiling in scorn. "Why, master, what you have taken such a fancy to is not a carnation even, it is only a pink."

"I do not care," said Harry, "what you call it. I like it, whether it be called carnation or pink."

The gardener looked at him with contempt.

"Pray what is the difference between them?" said Lucy; "my mother has told me, but I forget it."

The gardener told her, that one chief difference is in the roundness of the petals of carnations, and the jagged or pinked edges of the petals of pinks.

Lucy liked these edges, and she really thought some of the pinks prettier than the carnations. She told Harry so, in a low voice. "But I am afraid," said she;

“that the gardener would despise me if he heard me say so.”

“What signifies whether he despises you or not?” said Harry. “There is nothing wrong in liking a pink better than a carnation.”

The gardener, who did not hear what was said, fancied that they were debating, whether they should ask for one of his grand panjandrams, and he began to say, that he was sorry that he could not offer this, he could not give this to any body.

Harry assured him, that he need not make any apology, because they did not wish for them. Piqued by Harry's indifference, the gardener named several lords and ladies, who had admired his panjandrum above all things, and who had tried in vain to obtain it. It was a very great rarity, he said. Only two other people in England had a real panjandrum.

Harry liked flowers for being pretty, and did not care whether they were rare or not.

The gardener did not believe him. Soon afterwards he offered Harry some pinks, of a kind which he liked particularly.

“But, master, I can let you have them only upon condition, that you promise not to give any cuttings or layers of them to any one.”

Harry drew back with disdain, and said he would make no such promise.

The gardener said, that unless he would he should not have the pinks.

“Then,” said Harry, “I will do without them.”

He turned off abruptly, and walked away, but Lucy stood still, and said,

“I believe we may have them. Mrs. Frankland told us we might have any thing in this garden that we choose; and here she is coming back from the orchard.”

“Oh! that alters the case,” said the gardener, with a look of some mortification. “Then, master, you must choose what you will, to be sure.”

Harry turned back, and walked composedly along the sides of the carnation beds, writing down the names of those he chose, on a bit of paper. The gardener breathed freely, when Harry passed by the Panjandrum, and turned his back upon the Envy of the world.

Lucy whispered to her brother, "Did you see how much he was afraid that you should have chosen any of those, that are really valuable: and why did not you?"

"Because I did not like them, and I despise his mean reasons for liking them," said Harry, putting the paper and pencil into her hands. "Now go, Lucy, and choose."

Lucy, admiring her brother's independence, followed his example, and chose what she liked, without being influenced by the foolish wish of possessing what other people cannot procure. She did not choose either the Pride of Holland, or the Envy of the world.

Harry was quite right to adhere to his

own taste: here was no trial of complaisance or generosity.

Mrs. Frankland and their mother now returned from the orchard, and Harry and Lucy gave Mrs. Frankland their list. She looked it over, said she thought they had chosen well, and had been moderate in their requests. She called to her gardener, gave him the paper, and desired him to have the plants in readiness at the time she mentioned.

"Very well, ma'am," he answered, coolly looking over the list, which he saw was only of common flowers; but when she added, that he must also give some Dutch hyacinths, and tulip roots, the gardener's whole countenance changed, he exclaimed, "My Dutch tulips and hyacinths!" and throwing down a hoe that he had in his hand, he walked off, muttering to himself, "that it was well his mistress's head was not loose, or she would give it away."

Mrs. Frankland laughed good-humouredly at his anger. She bore with him,

she said, because he was an old and faithful servant, who had been long in the family before she was married. "Though you might not think it," said she, "he is generous to his relations, of all that belongs to himself, and covetous only of what belongs to the garden, of which he considers himself as guardian against his mistress's extravagance. But I cannot bear this sort of petty avarice and rivalry about flowers, in persons whose education ought to have raised them above such illiberality. I have heard of a lady, who, when she was asked by a friend for the roots of some particularly fine flower, ashamed to refuse, yet unwilling to give, boiled the roots before she sent them, to prevent the possibility of their growing."

Harry expressed the greatest indignation against this meanness.

They now entered the conservatories, and observed the flowers of a plant, which hung over the entrance of the peach-house. They looked as if they were cut out of

thick velvet, and were covered with honey. Their smell, which had been pleasant at first, soon became disagreeable and overpowering. Mrs. Frankland told Lucy, that this plant is called *Hoya carnosæ*; *Hoya* from the name of Mr. Hoy, the gardener, who introduced it into England; and *carnosæ* from the fleshy appearance of the flower. She had planted it at the door of the peach-house, because it is there a useful guard. Wasps are so fond of its honey, that they will, for this, leave untouched peaches and grapes. After they had seen the peach-house, they walked through the conservatory, where Mrs. Frankland pointed out a tree, called the Papaw tree, *carica papaya*, which had been brought to her lately from the West Indies. The gentleman who gave it to her told her, that it will grow twenty feet in three years; that its juice has the singular property of making meat tender; if the juice be rubbed on beef it makes it as tender as veal; and if an old fowl be hung on the trunk of this tree, it becomes, in a few

hours, as tender as a young chicken. This, it is affirmed, is a fact, which has been long known to those who have resided in the West Indies. But Mrs. Frankland said, as she had not yet tried the experiment, she could not assert it to be true.

At this moment, Harry put his hand to the mouth of one of the flues or pipes in the conservatory, and perceived that warm air came through it; but Mrs. Frankland told him, that this air was not well heated, and therefore did not heat the building as it ought. She said, that a man was just going to alter, and she hoped to improve them. Harry heard his father talking to this man at the other end of the conservatory, and he went to see what was doing.

His father turned to him, and asked, whether, if *he* were to place the pipe, he would put it at the top or the bottom of the building?

Harry answered, "At the bottom; because I know that heated air is lighter than air that is not heated, and therefore, if it is

let in at the bottom of the building it will mix with the colder air, and gradually warm the whole house as it rises to the top.

As Lucy walked on with Harry, she asked him how he knew that hot air is lighter than cold.

“As you might know,” said Harry, “if you recollect a diversion we were fond of when we were children, and which I should like this minute.” He puffed out his cheeks, and blew through his hand, as he turned his face up towards the sky.

“Blowing bubbles, you mean!” said Lucy; “but what then?”

“What do you think makes the bubble go up?” said Harry.

“It goes up, because it is lighter than the air.”

“And how comes that? What is it filled with?”

“It is filled with air from the mouth, blown through a tobacco pipe.”

“Well, whether it is blown through a tobacco pipe or not,” said Harry, “is the

air from your mouth hotter or colder than the outer air, do you think, when the bubble rises?"

"Oh! hotter to be sure; now I know what you mean. The bubbles go up, because they are filled with heated air. Indeed I might have known from this that heated air is lighter than cold air; but I did not recollect it at the right moment. I wonder how you came to remember it so well."

Harry said, that besides the bubbles, another thing fixed it in his mind. A thing which he had seen when she was away from home. A fire balloon, which went up because it was filled with heated air. He was one of the persons employed to hold the great bag of the balloon over a fire made of straw. "It was all flaccid at first," said he, "as my father called the bladder which you may remember he showed us."

"Yes," said Lucy; "and if your balloon were filled with heated air, it would expand. I know that."

“ Yes, but you do not know how it pulled,” said Harry. “ I felt it beginning to pull against my hands, as it filled out; and at last, when it was quite full, it pulled so hard that I could scarcely hold it. But I was desired to hold fast, and I did, though my knuckles were burning. The instant papa cried ‘ Let go,’ we all loosed it, and up it went, to a great height, quite into the clouds. Oh, the pleasure of seeing it go up! and the pain of my knuckles, which were all blistered, fixed the whole in my mind, so that you need not wonder at my remembering it.”

While they were talking in this manner, their father was still speaking to the workmen about the stove of the hothouse. They joined him, and listened to what he was saying. The man was asking Mr. Frankland, if he had seen the new method of heating houses, used in a neighbouring town. He had, and admired it much. It had been first attempted at the house of the gentleman by whom it had been invented, which it warmed most comfortably.

Then it was tried at the County Infirmary, where it also succeeded to the satisfaction of the medical men and the patients. It was the invention of a gentleman, who has for many years exerted his great knowledge of mechanics for purposes of domestic comfort; and who has, in the most liberal manner, devoted his wealth, his time, and his inventive genius, to public works, useful to his native town in particular, and to mankind in general.

At this moment they were interrupted. Some visitors had arrived, and they returned to the house. When Harry went into the room he saw ladies with no bonnets on their heads, and one with artificial flowers in her hair; though not much skilled in such matters, he thought this looked as if these people were not merely morning visitors, but would stay to dinner, for which, as Lucy knew by his face, he was very sorry.

The next time they were alone together, in their mother's dressing room, in

the evening, after the company were gone, Lucy asked her brother if he had not been unhappy all day since the time they were interrupted at the stove; but Harry said, that, on the contrary, he had been very happy; and that he had heard several entertaining things.

“At first,” said he, “when I saw that woman, with the artificial flowers in her head, I thought it would be a *company* day, and that it was all over with us.”

“That lady was very good-natured to me,” said Lucy, “in telling me something about the artificial flower which she wore. Did you observe it?”

“Not I,” said Harry. “Yes, I believe I did see it; it was like a lilac; and I was glad it had no smell, for I dislike the smell of lilac in a room. But what did she tell you about it?”

“That she brought it from Italy. She asked me to guess of what it was made. I looked close, and I touched it, for she told me that I might. It was not paper, nor

silk, nor gauze, nor cambric : I could not guess what it was, though I had an indistinct recollection of having seen something like it somewhere. It was made of the cocoons of silk worms. In Italy you know they have great quantities of these—in the silk worm's own country—and it is well to make use of them, instead of throwing them away.”

“ Yes,” said Harry, “ if there must be artificial flowers, and I suppose there must. That lady gave also an entertaining account of some travellers, who were stopped by banditti between Rome and Naples.”

“ Yes,” said Lucy, “ and of the little girl who had her mother's jewels given to her to take care of, and who concealed them in her doll's cradle, and who kept rocking the cradle and talking to her doll all the time the robbers were searching the carriage ; so that they never suspected where the jewels were, and went away without finding them. I do not think I could have had courage or

presence of mind to have done that. I wish I could."

"You do not know till you are tried, whether you could or not," said Harry.

"But what was I going to say? I cannot recollect," said Lucy. "Oh! I was going to ask whether you heard what that lady told me about straw bonnets?"

"Not I," said Harry. "I heard her beginning to say something about the price and the fineness of hats. Women's business, thought I, to which I need not listen."

"Yet it was worth hearing," said Lucy; "though it was about bonnets, gentlemen listened as well as ladies."

"I am ready to listen now," said Harry.

"In the first place, Harry, do you know what Leghorn bonnets are?"

"Yes, I believe I do. A sort of straw hats. I know the things when I see them," said Harry.

"Very well; and you must know, too, that ladies think they are much better, because dearer than others," said Lucy. "No, I mean much dearer, because better."

"Which is it? Are you sure," said Harry, laughing.

"Quite sure," said Lucy. "They are really better; they wear much longer, and bear wetting and crumpling. They are *infinitely* better."

"You know best. I am satisfied," said Harry. "That is settled; they are dearer because they are better. Go on."

"And they must be *much* dearer than the common straw bonnets, which are made in England, you know, because they are brought from a great distance, from Italy."

"Aye, from Leghorn, I suppose, from their name," said Harry.

"Yes, at Leghorn first, I believe, and for a long, long time, hundreds of years, I dare say ever since such hats have been worn, people never thought of its being possible to make them anywhere but in Italy. The straw is plaited differently, and they thought that sort of straw could be got nowhere but there. In short, they never thought of looking or trying what

they could do till lately. But now people have found out, first in America, I believe, then in England, and at last in Ireland — poor Ireland ! — they have found a sort of grass, the straw of which will do, and they have learned how to plait it as well as they plait it in Italy. That lady showed us two bonnets, her own and her daughter's ; her own she brought from Italy, and her daughter's was made in Ireland, and, as well as I could see, the Irish one was the finest of the two. And much better judges than I am, and people who looked through spectacles, and held magnifying glasses to them, said the same. Several ladies in Ireland, as she told us, have taken a great deal of pains to teach poor girls this straw manufacture. One lady, who learned how to do it herself, from some directions in a common newspaper, set to work, and tried experiments."

"Sensible woman !" said Harry.

"And good," said Lucy, "for it was to do good. And, after a great many trials,

she made a bonnet from the very beginning, with her own hands, from the first preparing the straw to the finishing ; and she won the prize for this, the best that ever was made, I believe."

" Oh ! now, Lucy, do not go too far. How do you know ?" said Harry.

" I tell you just what was told me, my dear ; that a person who saw it, and compared it with one which had been sent from Italy, to some French princess, declared that the Irish hat was full as good as the finest of fine Leghorn hats, which cost fifty guineas. And this Irish hat was made of a very common grass, called crested dogs-tail*, which grows even on bad ground. Its flower stalks are so remarkably harsh and tough, that cattle will not touch them, though they will eat the dry stalks of many other sorts of grass. But these remain all winter in the fields useless ; and they are called in Irish *trawnyeens*. When a thing

* *Cynosurus cristatus*.

is worth nothing, the Irish say it is not worth a *trawnyeen*. But now trawnyeens are made good for something, and for a great deal too."

"Would you know the grass if you were to see it?" said Harry.

"Yes," said Lucy, "I know it very well, and I will show it to you the next time we are in any field where it is."

"Do," said Harry. "I like the woman who stuck to the bonnet till she had succeeded."

"She succeeded in doing a great deal more than making one fine bonnet. That would have been no great matter, only ingenious," said Lucy; "but I will tell you much more, and much better. This kind lady taught several poor Irish girls to make these hats; and two, not older than fourteen, working in their own cottages (cabins they called them), made in one year twelve bonnets, and besides they did all the work that was wanted in the house as usual. Their twelve bonnets were sold

for a guinea a piece. A great many such have been bespoken, and are to be sent over to London. The children of those poor Irish, who, as you know we heard, were almost starving last winter, have now one good way, by which they may earn guineas for their fathers and mothers."

"That is good indeed," said Harry. "I am sure that woman who made the first bonnet, and taught them all, must be glad."

"Yes, I am sure I should, if I were in her place," said Lucy. "And, Harry, mamma told me, that if I can learn to do this plaiting, I may teach it to our poor widow Wilson's daughters. To-day I saw a little bit of it, which the lady, who told us all this, brought in her work-bag. She let me undo a bit of it, to see how it was done, and she gave us some straw, and we began to try."

"Now I know," said Harry, "why you were all plaiting straw so eagerly. I could not think what had seized you, when

I saw you all so busy with straws when I came back from playing. But now, Lucy, to go to another thing, for we have said enough about this — did you observe the old gentleman who sat in the arm-chair by the fireside ?”

“ The same gentleman, who, the first day at dinner, talked of Wedgwood’s ware, and of vegetable pie dishes ?” said Lucy. “ Yes, I saw him, indeed. He took a great quantity of snuff, and I could not bear —”

“ What ?”

“ *It*. Oh horrible, Harry ! — his pocket handkerchief —”

“ I did not see it,” said Harry.

“ I am glad of it,” said Lucy. “ I do not like him.”

“ You do not like him ! my dear. I assure you,” said Harry, “ he is a very sensible man ; for I heard him talking to my father and Mr. Frankland about stoves, and flues, and fire places, and hot air.”

“ Very likely,” said Lucy ; “ but I wish

that he had not had those two great streaks of snuff along the wrinkles of his waistcoat."

"Never mind that," said Harry; "I want to tell you something entertaining he told me."

"Well, do then, I would rather hear it from you than from him," said Lucy. "I hope, Harry, you will never take snuff."

"No, no, my dear; no danger."

"But when you grow old, my dear, great danger. So many old people do, and young too. Now I will tell you the names of all the snuff takers I know."

"No, no, no! my dear Lucy," said Harry, stopping his ears, "pray do not; but let me tell you about a little bird."

"A little bird—oh! that is another affair—I thought you were going only to tell me about stoves. What about a little bird?"

"It was about stoves too," said Harry; "you must hear that, before you come to the bird. Do you recollect, some one

said, that there was a disagreeable smell from a stove in the passage."

"Yes," said Lucy, "and the people began to debate whether it was a smell of smoke or of burnt air."

"Then it was, that my old gentleman asked if they knew what is meant by *burnt air*, and he began and told of a doctor* somebody, who tried some experiments to determine whether heated iron gives out any thing unwholesome to air, that passes over it, or whether it takes any thing away from it, so as to make it, in short, unfit for our breathing."

"So he took a bird, I suppose," said Lucy.

"Stay, stay; first he took a small cube of iron, and heated it to a great heat: I am sorry I forget the degree," said Harry.

"Never mind," said Lucy, "get on to the bird."

"And he put it into an exhausted receiver," said Harry.

* Dr. Desaguliers.

"The bird?" said Lucy.

"No, my dear, the cube of iron. I wish I had never told you about the bird."

"Well, well, I will not be bird-witted," said Lucy. "Papa, you know, told me, I was bird-witted once: but, Harry, I beg your pardon. Now, tell me; he took a small cube of iron, and he put it into an exhausted receiver."

"Yes," said Harry; "he placed the cube of iron so that whenever he let in air, it should all pass through a hole in the hot iron."

"You never told me of any hole in the hot iron," said Lucy.

"There I was wrong," said Harry; "I should have told you, that he had made a hole through the iron cube; then he let the air into the receiver, and it passed through and over the heated iron; and when this receiver was filled with this air, he put a little bird into it, and it breathed the air without seeming to be in the least

hurt, or showing that he felt any difference between it and fresh air."

"But the bird could not speak," said Lucy; "and we are not sure it liked it."

"Not sure, certainly," said Harry; "but now listen to the next experiment, and you will find what happened. The man made the same experiment with a cube of the same size of heated brass, and put the same bird in the same receiver, after it had been again exhausted, and filled with air which had passed through and over heated brass."

"Well," said Lucy, "and what happened?"

"The bird died," said Harry, "in a few minutes."

"Poor bird!" said Lucy. "The man was very cruel; I mean the experiment was cruel."

"No," said Harry, "because he tried the experiment for a good purpose, to save the lives and health of human creatures."

"That was good," said Lucy; "but I

think he might have tried the experiment as well without killing the bird. He should have taken it out, when he saw it gasping for breath, as I am sure he did before it died. And he should have let it recover in the fresh air."

"Certainly," said Harry, "it was cruel, as you say, to kill the bird, because it was unnecessary. But, except that mistake was not it a good experiment?"

She admitted that it was a good experiment; but she observed, that the lungs of birds and of human creatures are different, and she thought it not quite a certain proof, that because a bird cannot live in such or such air, that therefore it must necessarily be unwholesome for human creatures. Her mother, to whom she appealed, thought this was true, and so did Harry.

"How much we have had to say and think of, from what passed to-day," said Lucy. "And how many curious facts and entertaining stories we heard in conversation, though we were so vexed at being

interrupted when the visitors first came in!"

"Yes," said Harry, "I thought of that; and thought how right my father was, in telling me, that we may often learn as much from conversation as from books."

A BOATING party was proposed by Mr. Frankland, on the third and last day of their visit, and Harry and Lucy were invited to be of this party, at which they much rejoiced. They had never been in any boat. This had not a sail, it was to be rowed with oars. They walked down to the side of the river, which ran through the grounds, and they found the boat in a little creek, moored to a post in the bank. Lucy thought it a little dangerous to walk over the board that was laid from the land to the edge of the boat. One of the boatmen would have taken her by the arm, but as she saw Harry walk on fearlessly, she followed without assistance. They were desired to sit down as soon as they were in

the boat, and something was said about *trimming* it. How, or why, a boat was to be trimmed, Lucy could not guess, and she was curious to see what would happen. Nothing happened, but that every body sat still in their places, except one of the men who was to row, and who, sticking his oar against the ground, pushed off from the shore. Then crossing over Lucy's head with his oar, and bluntly saying, "By your leave, Miss," he succeeded in getting the boat out of the little creek, in which it had been moored.

Now they were fairly out in the river, and all the boatmen began to row, excepting one, who sat at the end of the boat, watching the way it was going, and guiding it by means of the rudder or *helm*, of which he held the great handle under his arm.

After they had rowed a little way this man made one of his companions change places with another, who was much heavier; and then seeming satisfied, said, "She is well trimmed now." Lucy per-

ceived that *she* meant the boat, and now understood, that by trimmed, he meant that the weight on each side of the boat was balanced.

All was new and amusing to Lucy; she listened to the sound of the oars, and watched the sparkling drops, hanging from their edges, as the men lifted them from the water. They raised them out of the water, not edgeways, but with the flat part, or *blade*, horizontal, as you would raise a spoonful of any liquid. The use of this, as Harry perceived, was to diminish the resistance of the air against the oars, as they were moved forward, in order to replunge them in the water.

His father told him, that this motion is called "feathering the oars."

"Now I understand," said Lucy, "that verse in the song of the jolly young waterman, which you used to sing, papa:"

"Did you not hear of a jolly young waterman,
Who at Blackfriars used for to ply?
He feather'd his oars with such skill and dexterity,
Winning each heart and delighting each eye."

As they rowed along, they saw a pretty villa on the banks of the river. Lucy suddenly started up in the boat, and asked Harry if he should not like to live in that beautiful place, with the gay veranda."

"Sit still, my dear," said her mother; "for if you overturn the boat, you will never live anywhere."

Effectually quieted by this suggestion, Lucy sat down instantly, and quite still, silently enjoying the fineness of the day, and the pretty prospect of houses, gardens, parks, and woods, as they rowed on, and observing the reflection of the trees and buildings in the clear river. A bird, with white out-spread wings, was skimming over the water, which Lucy wanted Harry to see; but he, close at his father's elbow, was intent on hearing what Mr. Frankland was saying of some foreigners, who had lately been at his house, in the course of a tour they were making through England. He had taken them out boating; and in going down this part of the river they had been particularly

struck, not merely with the picturesque beauty of the scenery, but with the appearance of wealth, comfort, cheerfulness, and elegance in the residences of our English gentry. The great *territories* and *palaces*, as they called them, of our high nobility, did not surprise them so much as the vast number and variety of the lawns, and pleasure grounds, and parks of our country gentlemen. One of these foreigners was French, the other, Italian. In Italy, there are fine places and fine gardens belonging to the nobility, but none of these comfortable habitations, fit for persons in the middle ranks of life. The Frenchman said, that these country houses were amazingly different from the comfortless *chateaux* in France. They had paid visits to several of our country gentlemen, and liked their mode of living so much, that even the Frenchman protested, that if he had not had the honour of being born a Parisian, he should prefer the lot of an English country gentleman to that of any other being in the universe. The Italian was further

struck by the liberty enjoyed, and the equal justice done to all, as far as he could see, in England. He found, that many of our most distinguished men have made their own fortunes, many risen by their own talents and exertions, from the lower ranks of life. He found, that in this country, though birth has great advantages, education does more ; and industry and genius have the road to fame, and wealth, and honours, open to them ; he would, therefore, as he declared, rather have been born in England, even in a lower rank, than in the highest class in any country, where such equal laws and liberty, and such strong motives for exertion, are not to be found.

Harry understood all this, though it might seem a little above his years, and liked it the better, perhaps, on that account ; besides, he enjoyed the praises of dear Old England.

There was in the boat a sailor, who was now called upon to sing for them, as he had a good voice, and knew many sailor's

songs; and there was a boy who played on the flute. This boy was Scotch, and sang for them several pretty Scotch boat songs.

The singing was interrupted by the man at the helm calling out rather unceremoniously to the boy with the flute, bidding him have done with his *noise*, for they had something else to mind now. They were coming, as he said, fast upon the *weir*; and the men, who had been resting upon their oars, letting the boat float with the current, while they listened to the music; now began to row *across* the stream, which was carrying them forward with increased velocity. Lucy imagined there was some danger, but what it was she did not know, for she had never seen a weir, nor had Harry; nor, if he had known, was it any time for talking. All were silent. The man who steered seemed intent on passing quickly through the current, and all hands joining in the pull, they reached and brought the boat safely into a little creek, where they moored her, by throwing a rope from her round the stump of a tree.

When they were all safely lodged on the bank, and while the boatmen were wiping their foreheads, Harry inquired if there had been any danger, and asked what was meant by the weir. Mr. Frankland said, he would show it to him soon, but they could not see it from the place where they were standing. They walked on a little way on the shore, and presently heard a sound, as of waters falling, but still could not see from whence the sound came. It became louder and louder, as they advanced, till, having passed the overhanging branches of a willow, which interrupted the view, they saw what caused the noise of falling waters. The stream was rushing down a step, formed by a long ridge or dam, which lay obliquely across the river. This ridge was the weir, and there might have been some danger if the boat had been carried too near it, by the force of the current.

They were now to walk on to a place, where they were to get into another boat, on a canal. As they passed along the bank, opposite to the weir, they had a full

view of it, as the waters, arching over its rounding brim, formed a length of low, white, and greenish cascade, sparkling in the sun, and by its fall indented with changing lights and shades. While Lucy watched and admired these, Harry inquired what was the use of this ridge, or weir, which he saw was not a natural step in the bed of the river, but which seemed to be built of mason-work, for some particular purpose.

Mr. Frankland directed his eyes to a mill on the bank, and told him, that the use of this weir was to dam up the river, so as to secure a constant supply of water, and to give a fall sufficient to keep the wheel of this mill in motion. Harry wished exceedingly to have a nearer view of the water-wheel and of the mill. Wind-mills he had seen and examined, but he had seen watermills only from the road. Mr. Frankland said, it would not take them above half an hour to walk to the mill and back again, and was willing to grant Harry's request; Mrs. Frankland did not like to refuse him, yet she seemed

doubtful; she looked at her watch, fearing that they should scarcely have time; she said, that she was anxious to be home in good time for dinner, because she did not like to keep an old friend waiting. However, if the mill could be seen in half an hour, there would be time; she promised to wait for Harry; and his mother said that she would sit down on the stump of a tree, and make a sketch of the pretty situation of the mill, while he went to look at it. No sooner was permission granted, than Harry darted off, and was sure he should be back again in less than half an hour. But time passes quickly when we are amused, and when we are following our own particular tastes. First, the great water-wheel was to be seen, with all its vanes, and he stood observing how the water turned it. It was, as the millwright who came out to them said, an *overshot* wheel. Then it was to be explained to Harry, what is meant by an *overshot wheel*, and the difference between this and an *undershot wheel*. This was a mill for grinding corn: he had seen flour mills

turned by wind, and as the construction of the mill work was, as his father told him, nearly the same in this as in those which he had seen, there was no occasion to go over it. Indeed, he would have returned directly, but that he wanted to look at a crane, which was used for lifting up the sacks of corn from out of the boats, to the granary in the upper part of the mill ; and for letting down the sacks of meal, when ground. Harry thought he had been but a few minutes looking at this, and a few more minutes were spent in seeing a sack drawn up, and five minutes more in examining the motions of a certain *bolting* or sifting machine, the operation of which, when explained by the overseer, particularly delighted him.

The overseer showed him, that though the wheat, when it had passed through the mill stones, came out crushed or ground, yet that the finer parts were mixed with the coarse flour, as well as with the bran, or outer coat of the grain. In this state it was first spread out on a loft, in order to cool, and then it was poured down through

a wooden funnel, or *hopper*, into the upper end of the bolting machine. This was a long hollow cylinder, surrounded with a sort of net work of wire, resembling gauze, but of three different degrees of fineness. It was fixed in a sloping direction, and the overseer having kindly stopped the motion of the machinery, showed Harry, that within the cylinder there was a frame work of brushes attached to a small iron axis, which passed through its whole length. The overseer, by pulling a cord, set this iron axis again in motion ; and Harry perceived that the flour, when rapidly whisked round by the brushes, was forced out through the meshes of the wire ; the finest flour passing through the upper and closest division of the gauze ; and so on, till nothing remained, but the bran which fell out at the lowest end of the cylinder. Each species of flour was received in separate boxes, from whence they were taken away in sacks, according to the various uses to which they were to be applied. The finest flour being employed in making the whitest sort of bread, or in pastry ; the coarser in household

bread, and the bran in a variety of domestic purposes.

Highly interested with what he had seen, because the patient overseer had made him comprehend it thoroughly, Harry hastened back to his mother, and was not a little astonished to find that they had been away an hour instead of half an hour.

Mrs. Frankland, however, who always hoped the best, said that they could make up for lost time, by walking quickly to the place where they were again to get into a boat.

“Quick time! March!” said Mr. Frankland, and on they marched, in as quick time as they could, till they reached the canal — a long level stripe of still water, which, as Lucy said to Harry, looked no better than a broad ditch full of water.

She saw many large boats on this canal, loaded with coals, others with goods of various sorts, and some crowded with people. To her mortification, they were to go on in one of the canal boats; and slowly they now went, nor was there any pleasant sound of oars. Instead of being

rowed by men, this boat was drawn on by a horse, who was fastened to it by a long rope, and who, walking on a path on the bank, the *trackway* as they called it, tugged on with his head down, and as slowly as his feet could step. Lucy thought he looked quite stupified, and as if he was walking in his sleep.

“Why do people make canals, papa?” said she.

He explained to her, that canals are made to supply the want of rivers, where they cease to be navigable, or in places where they do not naturally flow: he said, that canals are extremely useful for carrying easily, and cheaply, heavy goods, and numbers of passengers.

Harry supposed, that canals could be made only through flat countries, and in ground that was quite level. But his father told him, that they can be carried through ground that is not level.

“And how do they manage,” said Harry, “when they come to hills, because water cannot go up hill; we could not, I think, go safely in a boat down hill,

or down steps : you know we were obliged this morning to get out before we came to that ridge, that little step in the river, the weir."

" Yes," said Lucy ; " one of the boatmen said, and my own sense showed me, that it would have been very dangerous to attempt it ; the boat would have pitched forward, and filled with water, and we should all have been drowned."

" Then how do people manage when they come to uneven ground ?" repeated Harry. " Perhaps they do as we have done to-day, get out, and walk till they have passed over the hill, and then take to the water again."

" That was the case formerly," said his father, " and is still practised in some places ; for instance, in America, and even in this country, in some of the fens of Lincolnshire, they not only are obliged to get out of their boats, Harry, and walk, but must carry their boats along with them, over land, or over marsh, from one place where the canal stops to another,

where the ground, being nearly level, it can go on; but this is inconvenient; Harry, even to passengers, and consider what it must be where heavy loads are to be carried."

"Very inconvenient," said Harry. "Then I suppose people take great care, in the first place, to choose the most level parts of the country, for their canals, and to go round the hills, instead of going over them."

"True," said his father, "but sometimes they cannot go round them: what is to be done then, Harry?"

"I see nothing that can be done, but to cut through them, as we saw one of the hills we passed over in our journey, where, from the height of the banks, it appeared to have been cut down several feet, to let the road go through: the same must be done, I suppose, for canals, and where great stones, or rocks, come in the way, these must be blown up with gunpowder, as we saw men *blasting* away a rock, where they were making a new road. Then the rubbish, and stones, and

earth, must be carried away, and a level bed left for the canal."

"*Must* is a word easily said, Harry," observed his father; "but all this digging, and blasting, and carrying away of stones and earth, is extremely tedious and expensive; so much so, that it would be impracticable to have carried canals across parts of the country, where they now go, if it had been necessary to make the whole bottom, or bed of the canal, upon one level. The difficulty is obviated, by means of an ingenious contrivance, called a *lock*. We shall come to one on this canal soon, and then you will see how it is managed, that we pass over inequalities of ground, without being obliged to get out of the boat, and without danger of its being upset."

"That is the best of it," said Lucy. "Is it quite safe, papa?"

"Quite safe, my dear: if your eyes and your ears were shut, you would not perhaps know, that you were passing through a lock."

Harry determined, however, to keep his ears and eyes well open. Presently they came to two large wooden doors, which would have stopped the way across the canal had they been shut, but they were open, and flung quite back. Their boat passed on between the doors, without their feeling any difference in the motion, or perceiving any change in their position. The doors were then closed behind them, and they found themselves in a sort of box, or reservoir, filled with water, just large enough to hold their boat without striking against the stone work on each side, or the wooden doors at each end. There were two doors, opposite to those through which they had entered; these they found shut; but a sluice or sliding door was immediately after their entrance drawn up; and this gradually let off the water that was in this basin, or reservoir, and the surface of the water gently sunk, sunk, sunk down, with the boat upon it, with an imperceptible motion. Lucy could, as she said, only know

that they had moved, by seeing the height above, and observing, on the stone sides of the lock, the marks of where the water had been on their entrance. They continued thus gently sinking till they came to the level of the water in the canal at the other side of the gates, through which they were now to pass. When it came to this level, the men opened the gates, and the boat was drawn out, and went on without difficulty on the canal. His father bid Harry look up to the part of the canal, where they had been before they entered the lock, that he might see the height from which they had sunk.

“Now, Harry,” said he, “tell me how it happened, that when we first came into the lock, we found the water in it upon a level with the water in the canal above, on which we had been going?”

Harry answered, that he supposed, that before they had come up to the lock, men had opened the great gates, and had

let the water from the canal rush into the reservoir till it rose to a level.

“Not the great gates, Harry,” said his father: “the rush of the whole body of water from the canal would be too violent. Think again.”

Harry thought again, and said he supposed there were small sluices, on the side of the lock, next the upper part of the canal, similar to those next the lower, which he had seen opened; and he supposed that these sluices had been opened, before they came up to the lock, and had gradually let the water in.

His father told him, that this was exactly what had happened, and reminded him of a whistle, which he had heard, from one of their boatmen, some time before they came to the lock, which was the signal for the man at the sluice to open it, and get ready the water for the coming boat.

Harry was much pleased with this most ingenious contrivance. “It seemed

so easy," he said, "that he thought even he might have invented it."

"This is the case with almost all good inventions," said his father.

"How nicely and gently we sunk down, down, in the boat," said Lucy, "on the level water in the lock, while it was flowing out. As my father said, I am sure, if my eyes had been shut, I should not have perceived that we were going down. What a depth we sunk! What a step that would have been, Harry! for a boat to come down: impossible, without a lock; but if you can go up and down stairs in canals—"

"Stairs! I do not know that," said Harry; "but one step, certainly."

Her father told Lucy, that he had seen, in Scotland, on the Caledonian Canal, seven or eight locks, immediately following each other; and the people of the country called these *Neptune's stairs*.

Mr. Frankland was glad to see that Harry and Lucy had been so much pleased with the lock, as it was for the purpose of

showing it to them, that he had come home by the canal. Soon after passing through the lock they landed by the side of a road, where their carriage had been appointed to meet them. Mrs. Frankland rejoiced to see it ready waiting for them, and again she looked at her watch, as if afraid they should be late.

LATE they certainly were, and very late ; and cross, and very cross was the old gentleman, who had been kept waiting and starving, as he said, an hour and a half beyond the regular dinner time. Mrs. Frankland bore all he said, and all he looked, with such gentleness and good-humour, that Lucy wondered how he could continue angry. She thought, however, that he must be terribly hungry, and that when dinner came, and when he had satisfied his hunger, he would grow good-humoured again. No. At dinner he grew worse and worse. Every thing was wrong. The fish was overdone, and the venison was

over-roasted ; and some fault he found with every one of the many good things, which Mrs. Frankland, with persuasive words, recommended.

“ Try this, my dear sir, or try that.”

But nothing he tried would do. Mrs. Frankland looked sorry, and still kindly soothed him ; but at last he said something very provoking about ladies never being punctual, and seldom thinking of their absent friends. Harry could not bear this, and his natural bashfulness quite conquered by indignation, he called out in a loud voice,

“ That is very unjust !”

The old gentleman looked up from his plate at Harry, whose face was red all over.

“ Well done, my little turkey-cock !” said he, half laughing. “ What have you to say or to do with the business ?”

“ Only that it was all my fault,” said Harry.

He explained, and said, that he had staid too long looking at a mill, and talk-

ing about an undershot and overshot wheel.

“Mighty well for you and your mill,” said the old gentleman, in a tone between pleasantry and reproach; “but pray, young gentleman, what was that you said about ‘*Very unjust?*’”

“It was unjust to say that ladies never think of their absent friends, sir,” replied Harry; “because Mrs. Frankland, who is a lady, *did think* of her absent friends, and of you in particular; for she was very anxious to get home in time, lest you should be kept waiting for dinner, which she said, sir, that you do not like.”

“Who does, sir?” said the old gentleman, now joining in a laugh. “But since it was all your fault, I must be satisfied, and must be obliged to Mrs. Frankland for her anxiety about me. This hare is very tender, and not over-roasted, which, considering all things, is wonderful. Mrs. Frankland, let us make up our quarrel by drinking a glass of wine together.”

Mrs. Frankland’s good temper, and

sweet smile conquered him. His fore head unwrinkled, and he became quite good-humoured, and talked of old neighbours, and of his good old friend Mr. Wedgwood again; and of the Staffordshire canal — the *Grand Trunk*, as he called it — of which the late Mr. Wedgwood was the first proposer, and which has enriched so many individuals, who had shares in the original undertaking.

After dinner, when the ladies left the room, Harry followed them, for he did not understand what was saying, about *shares in navigation*, and the interest paid upon them. While the ladies were drinking coffee, the conversation turned upon the cross old gentleman, and bore rather hardly upon him; one lady in company declaring, that she thought Mrs. Frankland had been too kind to him; that, for her part, she should not, had she been in Mrs. Frankland's place, have thought herself bound to submit to his rudeness, or to bear his ill-humour. She went on to laugh at him for his epicurism.

But Mrs. Frankland stopped her. She said, that she was much attached to this gentleman; that he was an old friend of her husband's, and of his family, and had long shown them kindness, for which she felt grateful; and that the only way in which she could prove her gratitude was by trying to make him comfortable and happy in his declining years, which could not be done without bearing with his little foibles. His real benevolence, and excellent sense and information, made amends for them; his pettishness was soon over, and his kindness of heart always remained.

Lucy admired and liked Mrs. Frankland for speaking in this manner. She resolved, that, when she grew up, she would be equally good-tempered, and would bear with the foibles of old friends, even if they happened to be a little cross. Above all, she resolved that she would be as steady as Mrs. Frankland, in defending them in their absence.

In the evening, after the old gentle-

man had taken his nap, and was sitting in his arm chair, by the fire side, he caught hold of Harry's arm, as he was passing, and said to him in a gruff, but good-natured tone—

“Tell me, little man, why you are so curious about mills? Are you to be a miller, or a millwright, pray? Or what are you to be?”

Harry, who generally understood what was said to him quite literally, answered gravely; that he believed he was not to be either a millwright or a miller: that he did not yet know what he was to be; but, whatever he was to be, it could do him no harm to get all the knowledge he could. And he wished to learn all about mills, because it entertained him.

“And what do you know about them?” said the gentleman. “Can you tell me what keeps a mill going?”

“Wind keeps a windmill going,” replied Harry, “and water a watermill. There are other kinds of mills, which

are kept going by horses, and some are moved by men, and many by steam."

"Upon my word, you know a vast deal," said the gentleman.

"No, sir, I know very little," said Harry, bluntly, and looking ashamed, and not well pleased.

"Well, I will not affront you any more by flattering you, since I find you do not like it," said the old gentleman. "Come," added he, drawing Harry towards him, "we shall be good friends yet, you will see. I saw you playing with my grandson at marbles yesterday. Do you know how marbles are made?"

"No Sir," said Harry, taking one out of his pocket, and looking at it. "I should like to know how they are made so very round and smooth: I should think it must be difficult."

"It is: my friend Mr. Wedgwood told me, that he had found it one of the most difficult things he had ever attempted; and when I was on the Continent I inquired how they were made."



“And how are they made, sir?” said Harry.

“First they cut a certain sort of stone into bits of any irregular shapes, no matter what, nearly the size of a common marble. These they throw into an iron mill, in which there is a number of partitions, and to each partition strong rasps are fixed, in a slanting direction: the mill is worked by water, and is turned with great swiftness: the rubbing of the stones against the rough rasps, and against each other, rounds them, and by degrees smooths and polishes them, in the same manner as the gravel becomes rounded in the bed of a river. When they are formed to the proper shape, they fall through circular holes, made in the bottom of the mill, of the right size to let them through. From Nuremberg, the town where they are made, they are brought down the river Rhine to Rotterdam, and thence sent all over Europe, to all countries and places where boys play at marbles; and where do they not? And now

you know more about marbles than nine in ten of the hundreds of boys of your age, who have their pockets filled with them."

The backgammon table was now set, for the old gentleman usually played a game with Mrs. Frankland about this time every evening; but instead of going to it, he staid talking to Harry, and telling him of various things which he had seen when he was in Holland.

"When first I went to Amsterdam," said he, "I remember, 'as I approached the city, counting forty-six windmills all in motion. The Dutch have long been famous millwrights, and many of the contrivances, now in common use in our mills in England, were brought from Holland; for instance, one which you may have seen in your journey here. Did you take notice, that on some windmills there is a very small sort of fan-wheel, which stands out a little from the top?"

"Yes; I know what you mean, sir," said Harry.

"So do I," said Lucy. "When first I saw it, I thought it was a little wind-mill to frighten away birds from the corn."

"And do you now know the use of it?"

"I do," said Harry; "for my father showed me one, and explained it to me; the use of that little wheel is to turn the great sail-wheel towards the wind, by means of the wind itself, so that whichever way it blows, the mill continues to work. In those, which have not this ingenious contrivance, the mill must stand still every time the wind changes, and the miller cannot set it in motion again, without a great deal of trouble; he must haul round the whole top of the mill in an awkward way."

"Why? how?" said Lucy. "Do Harry explain the two ways in which these different windmills turn, or are turned. I have some idea, but still I forget exactly how it is."

"Oh! I am sure you know," said Harry.

“ Perhaps I *did* know ; but go on as if I did not, begin from the beginning ; first, if you please, with the awkward way, with that windmill which has no little fan-wheel.”

“ That common mill,” said Harry, “ is called a post windmill, because it is supported upon a post, which is fixed firmly at bottom, and which goes up through the middle of the inside of the wooden body, or tower-part of the mill. This tower is separate from the mason-work, and from the grinding wheels underneath ; it hangs on the top of the post, and can be turned round upon it.”

“ This way do you mean ? Like this ?” said Lucy, holding her pencil upright, and hanging her thimble on its point.

“ Something like it,” said Harry. “ But the great sail-wheel is fastened to the wooden tower, and one cannot be moved round horizontally without turning them both. Suppose the wind changes from north to south, then the tower itself must be

turned, so as to bring the front of the sails to the side opposite to that on which they had stood."

"How inconvenient! And how does the miller do this? for that tower, and the sails and all, must be a great weight," said Lucy.

"He could not do it without the help of a lever," said Harry. "There is a huge ladder, which is fastened to the upper part of the tower, and which reaches from that to the ground, sloping outwards, so as to be a prop and *stay*, to keep the mill fixed in the position in which it is to stand, with the sails facing the wind. But the wind changes, and the mill must turn. Then the miller lifts up from the ground the lower end of this great ladder, which he then uses as a long handle, or lever, by which he turns round the mill, till the sails are again properly placed."

"So much for the post windmill; now for the other," said Lucy; "that with the little fan-wheel, as you call it."

"That does the business cleverly, and without any trouble to miller or man. Only the top, not the whole body of this kind of windmill is moveable. The axis of the great sail-wheel goes through this moveable top, and therefore can be shifted round horizontally along with it: this top rests on rollers, so that it can move easily on the top of the solid stone wall of the tower. Now for the little wheel."

"Aye, the little ingenious wheel," said Lucy.

"That is so placed at first, that its vanes catch the wind whenever it does not blow upon the sails of the great wheel. So as soon as *great wheel* stops, *little wheel* sets a-going, and it sets in motion a train of wheel-work, all which I need not describe to you. I need only say, that it has the power gradually to turn the moveable top round, till it brings great wheel with its sails facing the wind; then great wheel sets a-going; and little wheel by this time, having worked away from the wind, stops. Its business is done, and

it rests, till it is wasted. When the wind again changes, so as to blow on its vanes, then it sets off again, and works the great wheel round to the right point, and so on continually."

"Very well, you understand it, I see," said the old gentleman, "if I may say that much without your thinking that I mean to flatter you."

Harry smiled; "but," said he, "there is a thing I do not at all understand about windmills. I saw some standing still, while others nearly in the same situation were going with the same wind: I was thinking what the reason of this could be; and I suppose that there must be something different in the way in which the vanes or sails themselves are sloped, or set, I believe I should call it."

"You think rightly, I believe," said the old gentleman. "I have a friend in France, a scientific man, who made a windmill, which continued working when all the other windmills in the neighbourhood remained motionless. The common peo-

ple used to gather round, and stare at it, and say, that it went by enchantment, for they could not conceive how it could go with less wind than their own; but this arose from the judicious position of the vanes, which had been placed so that the wind should act upon them with the greatest possible force."

"I wish I knew that judicious position," said Harry; "I have often tried to discover it in making little windmills, but I could only place the sails by guess. I should like to know the rule and the reason, and the best possible way."

"And I should be very glad if I could tell you all this, my dear, but that is beyond me. Learned men have thought and written much upon this very question; but I am not a man of science, or a mathematician, therefore I cannot explain it to you. I can describe only the things which I have seen and which I understand."

He then gave Harry an account of several things he had seen in Amsterdam. Harry knew that this city is built upon

piles. Lucy said, she recollected reading the number of these piles, which was prodigious.

Harry asked, whether any of them had given way, or whether the houses stood upright upon them.

"No," said the old gentleman; "the first idea I had when I entered Amsterdam was, that many of the houses were tumbling down, they were so much out of the perpendicular line, but still they do not fall."

Harry was going to ask the reason of this, but another question occurred to his mind, which he was afraid he should forget, if he did not ask it first. "Pray, sir," said he, "do you know if the Dutch are acquainted with the use of steam engines?"

"Oh! yes, certainly."

"Then why," said Harry, "do not they use steam instead of wind, to keep their mills at work?"

"Why should they?" said the old gentleman.

"Because," said Harry, "wind is un-

certain, they cannot have it when they please; and if they have not wind, their mills must stand still. If there is a storm, they cannot make the wind less or more, just as they want more or less force, or quickness; but we can manage steam as we please, at all times of the year, and in all weather."

"Very true, my little mechanic," said the gentleman; "the Dutch are now beginning to use steam engines; and what is more —"

What more he said, Lucy was in no condition at this moment to hear, for on the scattering of the snuff which he threw from his fingers, she was seized with a fit of sneezing, that seemed as if it would never end. When she recovered, she heard the old gentleman speaking of the embankments, or high and broad banks, which the Dutch have been obliged to raise to protect the country from inundations. These embankments are secured chiefly by mats, fastened down by willows, which are twisted together, and which remain after the

mats decay, and thus form the best barrier against the force of the sea.

"Willows!" said she, "such yielding things, which I can bend with the least touch; can they withstand the whole force of the sea?"

"Yes, exactly for that reason," said the old gentleman, "because they do not resist; just as you may have seen the most yielding manner do best against the torrent of anger, and the gentlest of women subdue the most violent-tempered men."

Lucy smiled; she was always ready for a simile, but she liked this extremely, and was pleased with its particular application. Harry's heart now opened. He drew close to the elbow of the arm chair, from which he had before kept at a certain distance, and he began to use his privilege of asking questions freely, which he had till now done only with great reserve. His mother soon called him away, and advised him and Lucy to go to bed, as they were to set off early the next morning to pursue their journey. They were sorry to go, and every

body seemed sorry that they were going. The old gentleman asked which road they intended to take, and when Harry's father answered, by Coalbrook Dale, he said that he was very glad of that, for the sake of his young friends.

"Perhaps I shall not be up when you set off in the morning," said he, "so shake hands, young gentleman, and fare you well. It is happy for you, that so early in life you have acquired such a desire for knowledge. To-morrow you will see—"

Mr. Frankland interrupted him, "My dear sir, do not tell him *what* he will see. Leave him the pleasure of surprise."

"GOOD-BYE." It was come to that melancholy word, and as Lucy put her head out of the carriage window, to say the last good-bye to Mr. and Mrs. Frankland, who were on the steps at the hall-door, shutters opened in a bedchamber above, the sash was thrown up, and the old gentleman put

out his head, and repeated "Good-bye! good-bye! and a good journey to you."

"Thank you, thank you, sir; and pray shut the window, or you will catch cold," said Lucy. "He was very kind to you, Harry, after all," continued she, as they drove away; "and told you a great many entertaining and useful things; and at last I liked him very well, though he did take so much snuff. And though he was a little cross yesterday at dinner, he made up for it afterwards. I do believe, Harry, that he loves Mrs. Frankland in his heart."

"Who can help it?" said Harry.

"I wish," said Lucy, "that when I grow up I may be such a woman."

"I wish you may," said Harry, in a tone that sounded gruff, because it was as much as he could do to command his voice to speak at all, he was so sorry to part with these kind friends. Lucy indulged him in his taciturnity, and began to examine a little red morocco memorandum book, which Mrs. Frankland had put into her hand at parting, and which she had held

till now unopened. On turning over the leaves of this book, she found some of the pages filled with close writing.

"Dear, good Mrs. Frankland!" exclaimed Lucy. "Look, mamma, she has written all this for us, with her own hand: and what do you think it is?"

" 'The Juvenile Gardener's Calendar, dedicated to Harry and Lucy, by their sincere friend, E. Frankland.' "

" 'Spring,' 'Summer,' 'Autumn,' 'Winter,' all in four little pages," said Lucy. "I am always puzzled with the long directions in gardening books, about heaps of things too, which I have not; but here, I see, are only such flowers and plants as we have, or ought to have, in our gardens, Harry; and," continued she, after looking over the calendar, "it tells me exactly all I wanted to know, about the times and seasons for planting and transplanting, and sowing seeds, and how to have successions of pretty flowers. I must read it to you, Harry." She read, and when she had finished, he joined in her delight, at find-

ing that it contained all, and no more than they wanted.

"And you read it much better, Lucy, than you *sometimes* read writing," said Harry.

"Because," said Lucy, "this is much plainer than writing is *sometimes*. Do you recollect, Harry, how I stumbled in trying to read to mamma your translation?"

"Yes, I knew you wanted to read it particularly well," said Harry, "but you *boggled* terribly: it made me very hot."

"Not hotter than I was," said Lucy. "I wanted to read it particularly well indeed."

"That was the very reason you could not," said Harry, "you were too anxious and frightened."

"But what frightened me was, that I could not make out the writing. I knew I was making nonsense of what I was reading, and I could not help it. Since you have set up to write a running hand like papa's, you run all your letters into one another, so that at last, in some of your words, there is not a single plain letter."

“Ah! my dear! I can show you in that very translation several—”

“Possibly; but then you make three kinds of *rs*, and when I have learned to know one of them, then comes the other, quite different; and all your *ms*, and *ns*, and *us*, and *vs*, are so alike, no human creature in a hurry can tell them asunder; and you never cross your *ts*, so how can I tell them from *ls*.”

“But I do dot my *is*,” said Harry.

“Yes, you do; but you never put the dots over the right letter; I can never guess to what heads the hats belong; and then, worse than all, you half scratch out, and half write over, and half turn one letter into another, and then repent, and leave it no letter at all. But all this I could bear, if you did not make vulgar flourishes.”

“Oh! Lucy, be just; I have left off flourishing, you must acknowledge, ever since you told me it was vulgar. I have never flourished since that day.”

“But that day was only last Tuesday,” said Lucy.

"I do not know whether it was Tuesday or Wednesday," replied Harry; "but I know it was the day you read, or could not read, my writing to mamma, and I have never flourished since."

"Poor Harry! I beg your pardon for reading your translation so badly," said Lucy; "the next I will read better, if I can."

"The next I will write better, if I can," said Harry. "Let me look again; how does Mrs. Frankland make her writing so plain?"

"And so pretty too," said Lucy. "It looks pretty because it is so even and straight; and it is distinct, because—let me see—she always makes the same letters the same way, that is one good thing; for then I know them again when I meet with them; and she leaves a little space between her words, so that we may see they are separate words; and she finishes each letter, and does not make her *ms* and *ns* so very much alike, that people cannot

tell the difference. The little *es* too are a little different from the *is*."

"Very little," said Harry; "if I hide the other letters, I defy you, Mrs. Lucy, to tell even Mrs. Frankland's *i* from her *e*."

"But look at the difference, Harry; the *e* is a little open at top; or, at worst, I know the *i* by the dot over it. Look, the hat is always on the right head, and I know the head by the hat."

"A woman's way, indeed, of knowing a head!" said Harry, laughing.

"Oh, Harry! when you come to laughing at women," said Lucy, "I know you have nothing else to say."

"Yes, I have," replied Harry. "Since you are so fond of reading Mrs. Frankland's writing, here is a little bit more for you; here is a page in your book, which you have not read."

Lucy took the book, but was disappointed when she saw this page was only a catalogue of the botanical names of the flowers and shrubs, mentioned in the *Juvenile*

Gardener's Calendar. She did not know the use, she said, of calling flowers and shrubs by Latin names, when they have good-enough English names, by which all people may know them, if they please. She confessed, that the only thing she had not liked in all that Mrs. Frankland ever did or said, was her having that day, in the garden, always told the Latin names of the flowers after the English.

"Harry, I know you think as I do, that you thought so at the time; that made me dislike it the more, because I was afraid you would think it was—you know what."

"I know," said Harry; "and I did not like it, I own."

"We will ask mamma," said Lucy.

They had been all this time talking to one another, on their own side of the carriage, and their father and mother, on theirs, were conversing on something perhaps as interesting to themselves. It was necessary to wait for a pause. At the first which occurred, the case was laid before

them, Lucy stating it with some hesitation, and ending by saying,

“ Am I wrong, father, to think it was pedantic ? Am I wrong, mamma, to say any thing about it ? ”

“ Not at all wrong to speak your opinion freely to us, my dear,” said her mother.

“ You would be foolish,” said her father, “ if you blamed without inquiring whether you were right or wrong ; but you would be wrong if you spoke to any stranger of a fault that you saw, or thought you saw, in those who had been kind to you.”

“ You do not think it was pedantic, then, mamma ? ”

“ No, my dear, I do not ; but before we can understand one another, we must settle what we mean by pedantic. What do you mean ? ”

Lucy said she knew what she meant, but she could not exactly describe it. She turned to Harry. First, he said, that it was talking Greek or Latin in the wrong place ; he added, that it was trying to show that

we had any sort of learning that other people had not. But this, Lucy thought, was rather vanity or ostentation than pedantry. They had heard people call things pedantic, which they did not think were so ; for instance, a boy had once said that Harry himself was a pedant, for talking of the siege of Syracuse, and of the machines used there, because the boy knew nothing about them, and disliked reading.

“ Then you perceive,” said his mother, “ that the meaning of the word varies with the different degrees of knowledge of those who use it. I remember when it was thought pedantic for a woman to talk of some books, which are now the subject of common conversation. Sometimes old-fashioned learning, and sometimes useless learning, is called pedantry ; and it is generally thought pedantic to produce any kind of learning that is so unusual, that it is not likely that the company is acquainted with it, or can be pleased by it. In short, pedantry may be said to be an ill-timed parade of knowledge.”

"To go back to Mrs. Frankland, mamma," said Lucy: "she knew that we were not acquainted with those Latin names."

"Yes, but she did not consider you as *company*. She did not display her knowledge to excite your admiration; she used those names in speaking to you, because she thought it might be useful to you to learn them. The knowledge of the botanical names of plants is not now unusual; most people we meet with are acquainted with them."

"I did not know that," said Lucy. "And now I recollect, mamma, when Mrs. Frankland was talking of plants to the artificial-flower woman, who did not seem to know any thing about the matter, she called them only by their common English names; therefore, I am sure she told the Latin names to us, because, as you say, she thought it would be of use to us. If she had wanted to be admired for her learning, she would have displayed it in company. So it is proved, Harry, that she was not pedantic, and I am very glad of it."

"But still," said Harry, who did not seem quite satisfied, "remember what mamma said, that useless learning is pedantry."

"Then the question is, whether this be useless learning or not," said his father.

"That is the very bottom of the question to which I want to get," said Harry. "What is the use of knowing all those long Latin names, when people may know the plants they are talking of as well by their own English names?"

"They may know them, and describe them as well, to English people, but not to foreigners," said his father. "Most well educated foreigners, French, Spaniards, Germans, Italians, Danes, or Swedes, understand Latin, therefore it is a sort of universal language, in which botanists, and persons of science, can make themselves understood by each other. In all books of botany the Latin is given along with the common name; and then the description of the plant to which this name refers can be applied by people in different countries.

I have a friend at Paris, who could not understand what was meant by a cowslip, because in French there is no distinguishing name for cowslip; it goes under the general word for primroses, *primevere*."

"Yet a cowslip and a primrose are very different," said Lucy.

"But," said her father, "if this French lady had been acquainted with the botanic name, she would have known the difference the moment it was mentioned, and the deficiency in the French vocabulary would have been rectified. I remember hearing a French lady talking to a gentleman about the beautiful laurier rose; the gentleman understood French, but he happened never to have seen a laurier rose in France, therefore he could not understand what she meant. She described it, but still he mistook it for a rhododendron; at last somebody mentioned its botanic name, *Nerium oleander*, and the moment the gentleman heard this Latin name, he understood what was meant, and he knew

it was the common oleander which he had often seen in English greenhouses."

Harry now understood the use of learning the Latin botanic names, and he was satisfied.

"Remember, my dear Harry," added his mother, "that I mean no more than that it is useful as a language, and as a means of acquiring knowledge."

Lucy said, that she would learn by heart all the botanic names of the common flowers in the garden calendar, which Mrs. Frankland had been so kind as to write in her pocket-book; and she begged Harry to tell her, whether many of them had any particular meaning, like those two which she had been told, *Hydrangea*, the water lover, or *Agapanthus*, the beautiful, because she thought she could then learn them more quickly by heart, and remember them better."

Harry said that he would, if he could, but that he would rather do it at another time. He wanted to look at a broad-

wheeled waggon, which was coming down the hill. And while he watched the shape and motion of the wheels, and asked his father some questions concerning them, Lucy was pitying the poor dog, who was chained underneath the waggon, and who, as he waddled along, apparently half dragged by the neck, looked very mournful. She was told, that his use was to guard the waggon, and that his being chained to it secured his always being near it. She wished very much that the man could be persuaded to loose him; a faithful dog, she thought, would guard his master's goods without being chained. Her mother observed, that it would be useless to talk sentiment to an English waggoner. Lucy wished that she had some money, that she might give it to buy this dog from his master, and set him free. Her mother told her, that even supposing she could buy this dog, the man would get another, and this dog would not perhaps be better off, as he might not find any body to feed him, "You

know, my dear Lucy, we could not take him with us. What should we do for the next dog we meet under the next waggon?"

Lucy saw the impossibility of freeing them all, and sighed. Her mother was glad to see that she had such humane feelings for animals, but said, "there is much we must bear to see in this life, that we cannot remedy; all we can do is, to take as good care as possible of those creatures of which we have the charge."

Lucy blushed: "I will take care not to forget to give poor Dash water when I have him again, mamma. I recollect one day —"

Here she was interrupted by Harry, exclaiming, "Father! pray look out of the window this instant! Do you see that streak of black powder in the track of the waggon, papa? I saw it dribbling from a barrel. Is it not gunpowder? May I get out and look?"

He spoke as fast as he could utter the words, and his father instantly called to the waggoner, stopped the carriage, and

jumped out, Harry following him. It was gunpowder. They ran after the waggoner, who either did not hear, or would not stop. When they overtook him, and showed him the gunpowder running out of the barrel, he, being a sulky fellow, was very angry with the barrel, and with the man who packed it, and with the man to whom it was going, and with every body but himself. He had no clear idea of the danger he had run, till Harry's father told him, that he had some years before known a waggon to have been blown to pieces, and men and horses killed, by just such an accident. Some gunpowder had been shaken out of a barrel in the waggon, and had taken fire, as it is supposed, from a spark struck from a flint in the road. This communicating with the gunpowder had blown up the whole. The waggoner scarcely credited the story, till he heard the name of the hill down which the waggon had been going, and then, as Harry observed, without any further question, he believed

it to be true. So it is, that ignorant people believe or disbelieve, without any reasonable grounds. They staid to see the barrel well packed, and safely stowed. Some of the passengers, who were sitting within the canvas roof of the waggon, and who had looked out and listened, now expressed much gratitude, and said they might have lost their lives but for this timely discovery of danger. The waggoner then grew warmer in his thanks, and, as he was repacking the barrel, said in his Somersetshire tone to Harry,

“Master, you’ve done uz a mortal good turn, I finds, and if zo be it was in my power to give you a lift any ways, I’d not be behind, you’d zee; but the likes of I can do little for the likes of you gem’men.”

Harry thanked him; he wanted nothing he said, but he was glad that he and his waggon were safe.

“How well it was, father,” said Harry, as they walked back together to the carriage, “that I saw the gunpowder running

out, and recollected what you had told me about the blowing up of the waggon."

"Yes," said his father, "you see how useful it is to observe what passes before your eyes, and to recollect what you know at the right time."

When Lucy heard what had passed, after rejoicing that waggon and waggoner were safe, she regretted, that when the man offered to do Harry a good turn, he had not said a word for the dog.

"I forgot the dog," cried Harry. "Father, will you stay for me three minutes? I will run and speak for the dog."

His father smiled, and back he ran. What he said, or in what words the waggoner replied, we cannot tell, for Harry never could remember, either the words he used, or those said to him; but the result was, as he informed Lucy, that the dog Lion was unchained, that the waggoner promised that Lion should have liberty to run after him by day, and that he should be chained only by night.

Lucy was proud of her brother's share of this affair, and, as was ever her custom when she was happy, she went on talking of every thing she could think of, and of all that she saw upon the road: while Harry, according to his custom, when he was well pleased with himself and particularly happy, was quite silent. After Lucy had exhausted every thing she could say, she perceived Harry's silence.

"What are you thinking of, Harry? are you still thinking of Lion and the waggoner?" said she.

"Not I, for there is nothing more to be done about them," said Harry. "I am considering what that very bright thing can be which I see out yonder, sparkling in the sunshine."

"I see it," said Lucy, "it looks like a monstrous diamond, twinkling between the trees. What is it, papa? look at it."

Her father thought it was the reflection of light from some weathercock, or polished

globe on the top of a building. As they approached nearer, they saw it was from the glass roof of a conservatory."

"Reflection of light!" said Lucy; "what do you mean, papa, by the reflection of light? and what is the difference between reflection and refraction, of which I have heard?"

Her father answered, "When the rays of light are thrown back from the surface of any polished substance on which they strike, for instance, from a polished piece of metal or of glass, they are said to be *reflected*. When the rays pass *through* any transparent body, and, in doing so, are turned from their direct course, they are said to be *refracted*, and this light is called *refracted* light."

"Do you recollect, Lucy," said Harry, "yesterday in the boat, you observed that the oar in the water looked as if it was broken? That was because you saw it through the water. Mr. Frankland told you that was the effect of refraction."

"I remember," said Lucy, "that he told me so, and that I did not understand at the time what he meant. I was ashamed to ask him more about it, and afterwards I forgot it; but you, Harry, can explain it to me, cannot you."

"Indeed I cannot," said Harry.

"But, papa, will you be so good as to make us understand it?"

"My dear, I cannot be so good as to make you understand it yet, till you have more knowledge: I am glad, however, Lucy, that you observed the appearance of the oar in the water, and that you wish to know the reason of what you saw. Seemingly slight observations of this sort lead to important discoveries."

"Do they, indeed, papa," said Lucy.

"Yes; but often observations such as these, though they might lead to great discoveries, if pursued, remain hundreds of years useless, because people do not try to find out the reason of what they have seen. As long ago as the time of Aristotle,

which is above two thousand years, among other questions in his works on natural history, he asks, why a stick appears bent when it is held obliquely in water? This question was never rightly answered, till about four hundred years afterwards by Ptolemy. The fame of several great philosophers, among the moderns, rests upon their discoveries of the rules or laws for measuring that refraction of light, on which the appearance of the bent stick in water depends. And not till the time of our great Newton, was the whole satisfactorily explained, or all the knowledge obtained, to which it has led. He, by pursuing this and other seemingly slight observations, and by trying experiments carefully, to find out the cause of what he had observed, made his great discoveries of those properties and laws of light, which we call the laws of reflection and refraction. Even from considering the colours on a soap bubble, which many others had observed before him, but of which they had made no use,

he was led to some of the most important conclusions respecting vision and colours."

But here all philosophical conversation ceased, interrupted by the sound of the horn of a mail coach. Harry and Lucy quickly darted their heads out of the window; for though oftentimes seen, Lucy never willingly missed the passing of a coach, stage or mail. This was, as Harry guessed, the royal mail, with its guard behind, the scarlet man with the gold-laced hat, blowing the authoritative trumpet to clear the road. Proud as a king on his throne, sat the many-caped, many-cravatted coachman on his box, with his four fine horses even in hand, who kept on in full trot, regardless of the load behind — the whip idle in the master's hand, except that once he flung out the long lash with a light touch, to remind one careless horse, that he must draw fairly, and to bring him into true trotting time. As they passed, Lucy admired the horses much, but the harness more.

"Nice!" said she, "and nicer than any gentleman's harness. Bright brass rings standing upon the horses' foreheads, with twinkling gimmals glittering in the sun."

Regardless of the harness and the twinkling gimmals, Harry had eyes only for the horses.

"What fine creatures! and how they go! Oh, father! look! how they turn the corner," cried Harry, leaning out of the carriage, to watch them till they were quite out of sight.

The road for the rest of this stage was, as Lucy observed, a stupid straight line: she could find nothing to do, but to count the carriages they met, in the last five miles. Her father told her; that on the Bath road he had once met eleven stage coaches in five miles. But on this road, she met, in five miles, only one heavy laden waggon, and twelve coal carts. Harry wondered that she continued still looking out of the window, when there was nothing to be seen but coal carts:

she said, she had a reason for this; and he left her to take her own time to tell it, which did not happen this stage.

"HARRY! do you remember, that the old gentleman told us last night," said Lucy, "that we should be *surprised*, before this day's journey should be over?"

"So he did," said Harry; "but I have been so happy all day, that I never thought of it till this minute."

"I have been very happy too," said Lucy, "but I have thought of it sometimes. And now that dinner is over, and that evening is coming on, it is time to think about it. I wonder, Harry, what it can be."

Lucy was standing in the parlour of the inn, where they had dined, and she looked all round the room, and then out of the window, as she spoke.

"There is nothing surprising here I

am sure," said she. "But I heard papa order, that the horses should not be put to yet, not for two hours. What can be the reason of that, Harry?"

"We are to walk through some park, near this town, I believe," said Harry, "and the carriage is to meet us at the farthest gate, and we are to see some house. Come! Come Lucy! Papa is calling to us to follow him."

Lucy followed with great alacrity, certain that they were now going to be surprised. But they walked up an avenue of beech trees, and reached the house without meeting with any thing surprising; and Lucy was disappointed, when she found that her father and mother came to this house only to look at some pictures. Neither Harry nor Lucy had yet any taste for pictures, and their mother therefore advised them to divert themselves by running about the pleasure grounds, which amusement they were permitted to enjoy, upon her answer-

ing for them, that they would not touch any of the flowers or shrubs. First they went through all the flower gardens, then through the park, and by the river side, and up again through a wood on the banks, till the red light of sun-set, which they saw on the stems of the trees, warned them to return from whence they came. They were afraid of being too late, and of keeping their father and mother waiting; but luckily they met the wood-ranger going home from his work, and he showed them a path, which took them the shortest way to the house. Instead of being too late, they found that they need not have run so fast, for their father and mother had not yet finished looking at the pictures.

“Let us sit down then, and cool ourselves quietly,” said Lucy. “Harry, only think of papa and mamma having been all this long time, looking at pictures! How tired I should have been, if I had been standing all this while, with my neck bent back, staring up at them. Harry, do you

think, that when we grow up, and set out upon our travels, that we shall ever be so fond of pictures as to stand looking at them so long?"

"Perhaps we may," said Harry, "though we do not care about them now. I remember some time ago, I never thought of looking at prints, except of machines; but ever since the day I saw the prints in Don Quixote, I have grown fond of them."

"Yes; and how happy we were together," said Lucy, "looking over the prints in Pyne's Microcosm."

"True, I forgot them," said Harry. "I always liked those, because they are so like things and people we see every day."

"And the prints in the Arabian tales," said Lucy, "though they are not like things we see every day, or any day, or that we can ever see in reality, you like those, do not you, Harry?"

"I do," said Harry, "some of them."

“Some of them,” repeated Lucy. “Very right, so do I. Those that are like my ideas of what the sultans, and viziers, and Fatimas, and their turbans, and Coge Hassans might be. But some others I do not like, such as Aladdin’s genius of the lamp, and the African magician, because they do not come up to my imagination of them. Harry, do describe to me your image of the African magician.”

It was a difficult task, and Harry was glad to be relieved from it, by his father’s calling to him, to desire he would see if the carriage was come to the park-gate. It was there waiting, and by the time they got into it, the sun was set, and it was growing dusk. By the time that they reached the end of the next stage, and had drank tea, it was quite dark. They were, however, to go on another stage this night. Lucy, who did not much like travelling in the dark, observed, as her mother was getting into the carriage, that the coach lamps were not lighted.

"Never mind, my dear," said her father, "we shall have light enough soon."

"Soon! Oh no, papa, begging your pardon," cried Lucy, "there will be no moonlight these two hours. I can show you when the moon will rise, by my new pocket-book, papa."

"Very likely, my dear," said her father; "but, Lucy, do not stand talking on the step of the carriage."

At the moment when her father was giving her this advice, one of the horses was startled by a light, and, giving a sudden jerk to the carriage, Lucy was thrown from the step backward, and must have fallen under the wheel, but that her father caught her in his arms, and set her upright again. Into the carriage she went directly, and while yet trembling with the fright, her father repeated his advice.

"While you live, child, never again stand in that manner on the step of a carriage, without holding by something. I

assure you, that you put yourself into much greater danger at that moment than any you are likely to meet with from the darkness of this night."

Lucy hoped that her father did not think that she was a coward, and after some minutes' silent submission, she expressed this hope, and began to defend her character for courage, by reminding Harry of all the instances she could recollect of her *never* having been afraid in a carriage. Harry said nothing. "I cannot see your face, Harry. I hope you are agreeing with me."

"No, I am laughing ; for I think you are a little afraid at this minute. I feel you squeezing close to me, because we are going down the hill."

"Think, and talk, then, of something else," said her mother ; "and do not tell Lucy she is a coward, or you will make her one. Lucy, my dear, there is no danger ; but if there were ever so much, you cannot alter it."

"No, mamma; only I wish he would not go quite so fast," said Lucy. "Would you speak to him?"

"No, I cannot teach the postillion to drive; can you, Lucy?"

"No, indeed, mamma," said Lucy, laughing, or trying to laugh.

"Then we had better let him follow his own business, which he understands, and which we do not."

"Very well, mamma; I know you are right, and that there is no danger now. We are down the hill, I feel, and it is all over nicely. But, mamma, suppose there was danger, and that the horses were really what is called running away, what would you do?"

"Sit still. The only thing which would not increase my danger," answered her mother.

"Could not you get out, mamma?" said Lucy.

"I could, perhaps, but I would not attempt it; because I know it is the most ha-

zardous thing that could be done," said her mother.

"Yes," said Lucy's father, "I believe that more lives have been lost, and more limbs broken, by persons attempting to get out of carriages when horses were running away, than ever were lost by overturns. All who have had experience can tell you, that the best thing you can do is to stay quietly in the carriage till the horses stop, or are stopped. If you make any noise, or scream, or call to the person who is driving, you endanger yourself more, because you distract his attention, and you may be sure that he is doing the best he can, because he is probably as fond of his life as you are of yours. And as to driving, probably *his* best is better than *your* best."

"Certainly, papa; but *if*—" said Lucy, and there she paused.

"If what?"

"I am not sure whether it is right to say it, papa; but I have heard, that coachmen and postillions are sometimes drunk,

and if he was drunk, he would not know how to drive."

"And do you think that his being drunk would make you know how to drive?" said her father.

Lucy laughed again, because Harry laughed.

"But, papa, I should know better than he did, if he had lost all sense."

"True; but I would not advise you, as a little girl, or even if you were a woman I should not advise you, to attempt to direct or argue with a drunken man; for, besides the danger of his giving some rude answer, either the coachman would be too drunk to understand any thing, or he would not; as long as he could understand any thing, it is probable he would understand what he habitually knows best, how to drive. If he be so far intoxicated as not to know how to do that, he would be still less able to comprehend your reasons or directions, supposing them to be ever so good."

"Very true," said Lucy. "She declared that she never should think of talking to a drunken coachman or postillion, but she hoped that she never should be driven by one."

In which hope her mother joined her. "Lucy, my dear," said she, "when I was young I was afraid in a carriage, and I will tell you how I was cured."

"How, mamma?"

"I was cured of my fear for myself by a greater fear for another person. I used to be sent out airing with a lady, who had lost the use of her limbs, and I was so much afraid for her, that it took my attention away from myself. She was very cowardly; I was taken up in quieting her apprehensions; and I saw, that nine times in ten, when she was alarmed, there was no cause for fear. This encouraged me the next time, and so on: besides the feeling, that if there were any danger I must act for her, was a motive to me to keep my senses and presence of mind."

"As to that last," said Lucy, "I think, at least I fear, that it would have had a contrary effect upon me, and that I should have been ten times more afraid with the helpless person in the carriage."

"No," said Harry, "I think I should have felt as my mother did."

"What stops us? What is the matter," said Lucy.

"Matter! nothing in the world, my dear," said Harry, laughing. "Only we are stopping till the turnpike gate is opened, and till this old man, with a lantern, has fumbled the key into the lock."

Lucy joined in his laugh, and said, afterwards, "Laughing is very good for curing people of being afraid foolishly; for when you laugh, Harry, I know that there is no danger, or you could not be so merry. And now—it is very extraordinary—but I am no more afraid than you are, Harry. I will prove it to you. I will think of any thing you please. I can *cap* verses with you, if you will."

"No, thank you, not yet. I do not know enough to cap with you yet, my dear. The little that I know is from Shakspeare, and that is blank verse, which will not do for capping."

"But it will do for repeating," said Lucy; "and I wish you would repeat some of the quarrel of Brutus and Cassius, which we read together."

"I will try," said Harry; "where shall I begin?"

"Begin," said Lucy, "with Brutus's speech."

"What! shall one of us,
That struck the foremost man of all this world,
But for supporting robbers, shall we now
Contaminate our fingers with base bribes?"

Harry repeated this as if he liked it, and went on through all Brutus's part of the quarrel. He said he could not forget any of this, because he felt it. He admired Brutus, and Lucy pitied Cassius. His mother observed, that he liked dramatic poetry better than descriptive. Lucy, however,

thought some descriptive poetry was beautiful, and repeated to him the description of Queen Mab and her chariot of the hazel nut, made by the joiner squirrel, "time out of mind the fairies' coachmaker." This Harry liked well. Also some of the fairies in the "Midsummer Night's Dream," who "light their tapers at the fiery glow-worms' eyes." And Harry admired Ariel in the "Tempest," whose business it is—

—— "To tread the ooze of the salt deep;
To run upon the sharp wind of the north;
To dive into the fire, or ride on the curled clouds,
Or put a girdle round the earth in forty minutes."

And he could conceive delicate Ariel's pleasure in killing the canker in the rose buds, flying on the bat's back, or lying in a cowslip's bell. But for Pope's elegant Ariel, and the "fifty chosen nymphs of special note" he cared but little. He well knew that his mother admired them, but he was too sturdily honest to affect admiration which he did not feel. He thought it was his fault.

His mother told him, that perhaps he would like them hereafter, and that in the meanwhile he need not despair of his own taste for poetry.

Harry observed how much more easy he found it to learn lines which he understood, than to get by heart lists of names. He said, that he recollected having read in *Baron Trenck's Life*, that when the King of Prussia wanted to try Trenck's memory, he gave him to learn by rote a list of fifty strange names of soldiers in a regiment. Trenck learned them quickly.

"I am glad," said Harry, "that I was not in his place, for his majesty would have thought me quite a dunce, and would have decided that I had no memory. It is much more difficult to learn nonsense than sense," continued Harry: "there is something in sense to help one out."

"Unless it be droll nonsense," said Lucy; "but when it is droll, the diversion helps me to remember."

Harry doubted even this.

Their father said he would, if they liked it, try the experiment, by repeating for them some sentences of droll nonsense, which were put together by Mr. Foote, a humorous writer, for the purpose of trying the memory of a man, who boasted that he could learn any thing by rote, on once hearing it.

“ Oh ! do let us hear it,” cried Lucy ;
“ and try us.”

“ Let us hear it,” said Harry ; “ but I am sure I shall not be able to learn it.”

“ It will be no great loss if you do not,” said his father.

“ Now, Lucy, pray sit still and listen,” said Harry.

But Harry’s power of attention, which he had prepared himself to exert to the utmost, was set completely at defiance, when his father, as fast as he could utter the words, repeated the following nonsense, abruptly beginning with —

“ So she went into the garden to cut a cabbage

leaf, to make an apple pie; and at the same time a great she-bear coming up the street, pops its head into the shop. 'What! no soap?' So he died, and she very imprudently married the barber; and there were present the Picninnies, and the Joblillies, and the Garyulies, and the grand Panjandrum himself, with the little round button at top; and they all fell to playing the game of catch as catch can, till the gunpowder ran out at the heels of their boots."

"Gunpowder at the heels of their boots! horrible nonsense!" cried Harry; while Lucy, rolling with laughter, and laughing the more at Harry's indignation, only wished it was not dark, that she might see his face.

"Well, can either of you remember or repeat any of this?" said their mother.

Lucy said, that if it had not been for the grand Panjandrum, she was almost sure she should have been able to say it; but she was so much surprised by meeting the grand Panjandrum himself again, and so diverted by his little round button at top, that she could think of nothing else; be-

sides, laughing hindered her from hearing the names of all the company who were present at the barber's marriage : but she perfectly well remembered the Piccaninies ; and she knew why she did, because their name was something like *piccanini* ; and this word had been fixed in her head by a droll anecdote she had heard of a negro boy, who, when he was to tell his master that Mr. Gosling had called upon him one morning, and could not recollect his name, said he knew the gentleman was a Mr. *Goose-piccanini*."

" So you see, Lucy," said her father, " that even with you, who seem to be yourself one of the numerous family of the Piccaninies, or of the Goose-piccaninies, there is always some connection of ideas, or sounds, which helps to fix even nonsense in the memory."

" Papa, will you be so very good as to repeat it once more. Now, Harry, once more let us try."

" I would rather learn a Greek verb,"

said Harry. "There is some sense in that. Papa, could you repeat one?"

"I *could*, son, but I will not now," said his father; "let your sister divert herself with the grand Panjandrum, and do not be too grand yourself, Harry. It is sweet to talk nonsense in season. Always sense would make Jack a dull boy*."

The grand Panjandrum was repeated once more; and this time Harry did his best, and remembered what she went into the garden to cut, for an apple pie; and he mastered the great she-bear, and the no soap, but for want of knowing *who* died, he never got cleverly to the marriage with the barber. But Lucy, less troubled concerning the nominative case, went on merrily, "and she very imprudently married the barber." But just as Lucy was triumphantly naming the company present,

* Future commentators will observe, that this alludes to the ancient British adage,

"All work and no play makes Jack a dull boy,
All play and no work makes Jack a mere toy."

and had got to the Joblillies, Harry, whose attention was not so wholly absorbed, as to have no eyes for outward nature, exclaimed—

“ Father! father!—Look! look! out of this window. A fire! a fire! a terrible fire it must be. The whole sky yonder red with it.”

“ Terrible!” said Lucy, looking out. “ It must be a town on fire.”

“ Father!” repeated Harry, much astonished by his father’s silence, and composure, “ do not you see it?”

“ I do,” said his father, “ but it is not a town on fire. You will see what it is presently.”

A dead silence ensued, and the grand Panjandrum was forgotten, as though he had never existed. They drove on, Harry stretching out of one window, and Lucy leaning out of the other, while her mother held her fast, lest the door should open.

“ Harry, what do you see? I see fires,

flames!—great sparks flying up against the sky. Now I see, I do see, mamma, a house burning—there, there, mamma, at a distance, flames coming out at the top!”

“On my side, I see flames coming out of the ground,” said Harry.

Lucy rushed tumbling over to her brother's side of the carriage, bidding him look out at her house burning.

“Fires indeed! the whole country is on fire,” said Lucy.

“I suppose they are burning the grass, or a wood,” said Harry, endeavouring to regain his wonted composure, and to make sense of it; “but certainly there is a house on fire, father! flames red as blood bursting from the top!”

“And we are coming nearer and nearer every instant,” cried Lucy, “the road, I see, is going through the middle of these fires; Oh, father! mother! will you call to the man, he must be going wrong.”

“He is going quite right, my dear,” said

her mother : " keep yourself quiet, there is no danger, as you may see, by our not being alarmed, for you, or for ourselves."

These words, calmly pronounced, tranquillized Lucy, and Harry determined to wait the event, and not utter another word, whatever he might see. He was quite certain, by his father's composure, that there was no danger, either for themselves or for other people ; but this security left his mind more at liberty to feel curiosity, and very curious he was to know what was coming, how it would end, and, above all, how it would be accounted for.

They were driving now along a raised road, with fires on each side of them: flames seemed to burst from the ground at intervals of a few yards. Their deep red colour and pointed shape appeared against the dark night, far and wide as the eye could reach. The fires near the road made it as light as day.

" My father might well say we should have light enough," thought Harry.

“ I wonder the horses are not frightened by the fires,” thought Lucy: she had been for some time breathing short, in dread every instant that the horses would start off the raised road, and overturn the carriage, or plunge and throw the man, or set off full gallop. When none of these things came to pass, and when she saw the postillion so inconceivably at his ease as to lean over, and pat his horses, and then to take off his hat, and tighten the band, and try it again and again on his head, till it fitted, Lucy began to breathe more freely, and she observed how plainly they could see the man and horses, and the black shadow of the carriage upon the road.

Then exerting herself to find something to say, to show she was not afraid, she looked for the burning tower, but it was concealed by a turn in the road, or it was confounded with other distant flames.

“ It is like the country of the fire-worshippers in the Arabian tales,” said she ;

"and there they are," pointing to a group of figures. She saw by one of the fires, nearest the road, figures with pale faces, like spectres, the light shining strongly on them. She could see the man's bare arms, and his shovel, as he shovelled up the burning mass. "And the boy standing by, and the woman with the child in her arms, quite like a picture I have seen somewhere."

"But never anywhere," said Harry, "did you see such a real sight as this — all those lone fires for miles round, burning how, or for what, I cannot imagine."

"It is like the infernal regions! is not it, Harry?" said Lucy.

"I never saw them," said Harry, "nor any thing like this! it is very wonderful. What can the fires be for? signal fires?" No, thought Harry, there are too many, and on flat ground.

"Signal fires are always on hills, are not they, father? I see these fires near us

are from little heaps or hillocks of earth ;” but whether they were artificial or natural, made by men’s hands, or thrown up by subterranean fires, Harry could not divine. He wished to find out, he desired not to be told, and yet he almost despaired of discovering.

“ Father, I have read in some book of travels, of fires that burst out of the ground, of themselves. And I have heard, of some lake of pitch, or some — what do you call it ?”

“ Bitumen, do you mean ?”

“ The very thing I wanted ; father, are these fires of that sort, from bitumen, or do they burst out of the ground of themselves ?”

“ Not exactly either,” said his father, but those are both good guesses.”

“ The fiery tower again, brother !” cried Lucy. They came near enough to it now, to see its dark form, and even to hear the roaring of the fire. The body of flame undiminished, undiminishing, kept spouting

up from the top of the black tower, blown to and fro by the wind, nobody near or heeding it. When the road brought them to the other side of the tower, they saw an open red arch underneath, which seemed to be filled with a sloping bed of fire.

Harry had often seen a lime-kiln burning in the night. "It is a lime kiln, I do believe, only of a different shape from what I have seen."

"No," said his father; "but that is a sensible guess."

"Then it is a foundry! I have it now. I remember the picture in the Cyclopædia. It is a foundry for melting iron or brass. Now I begin to understand it all."

"And there are others of the same sort," said Lucy, "coming in view. And what is that black shadowy form moving up and down regularly, and continually, like the outline of a steam engine?"

"Like the great beam. It is a steam engine," cried Harry. "I see others. There they are, going on all night long,

working, working, working, always doing their duty, by themselves, and of themselves ; how very—”

“Sublime,” said Lucy.

His father told Harry, that he was quite right in supposing that these were founderies. As to the fires, he said, most of them were low ridges of coal, which were burning into coke, for the use of the forges. The process was very simple. After the coals were set on fire, a man was employed to cover them with ashes, through which the smoke could escape, till they were sufficiently burned. Coke, he told them, gave out a more steady and intense heat after the gas and smoke were driven off. Some of the fires, he added, might perhaps proceed from the refuse small coal, which were known occasionally to ignite spontaneously, and were suffered to burn, as there was no danger of their doing any mischief in this waste land.

When this explanation was given, Lucy's interest a little diminished, with the mys-

tery; but Harry's increased when he considered the wonderful reality.

"I shall like to see this country by day light," said Harry; "and to learn what those numbers of steam engines are doing."

"That must be for to-morrow," said his father.

WHEN they visited the fiery moor by daylight, they saw only a black dreary waste, with half burning, half smothering heaps of dross, coal, and cinders. Clouds of smoke of all colours, white, yellow, and black, from the chimneys of founderies and forges darkening the air; the prospect they could not see, for there was none. It was a dead flat, the atmosphere laden with the smell of coal and smoke. The grass, the hedges, the trees, all blackened. The hands and faces of every man, woman, and child they met, begrimed with soot! The very sheep blackened! not a lamb even with a lock of

white wool, or a clean face. Lucy said, that it was the most frightful country she had ever beheld. Harry acknowledged, that there was nothing beautiful here to be seen; but it was wonderful, it was *a sort of sublime*. He could not help feeling a great respect for the place, where steam engines seemed to abound, and, in truth, to have the world almost to themselves. These laboured continually, in vast and various works, blowing the huge bellows of the furnaces of smelting houses, forges, and founderies, raising tuns of water each minute, to drain the depths of the coal mines. The strokes of the beams of the steam engines were heard at regular intervals, and the sound of the blast of the furnaces at a distance. As they approached the founderies the noises grew louder and louder, till, as they entered the buildings, the roaring of the draft was tremendous. Lucy, involuntarily holding her breath, looked up to her father; she saw his lips move, but she could not hear what he said. She held fast by

his hand, and stood still. She saw an immense furnace, full, as she thought, of liquid fire, but it was red-hot liquid metal. One man with brawny arms, bare up to the shoulders, and a face shining with perspiration, was carrying this fiery liquid in a large ladle. Another poured it out into moulds of sand. Some men with white caps on their heads, and pale fire-lighted visages, were hurrying to and fro, carrying, in long-handled tongs, masses of red-hot metal. Others, seen in the forge at a distance, were dragging out red-hot bars, while two were standing with huge hammers raised, waiting the moment to give their alternate blows. Lucy tried to make Harry understand, that she thought the men were like Cyclops; but she could not make him hear the words. In this place, it seemed in vain for human creatures to attempt to make use of their voices. Here wind and fire, the hammer, the bellows, the machinery, seemed to engross the privilege of being heard. The men went on

with their business in silence, only making signs when they wanted you to stand out of the way.

While they were seeing the foundery, they were met by Mr. Watson, the master of the works, to whom Harry's father had a letter of introduction. He apologized for not having been able to attend them himself. But now, he said, he was at leisure for some hours. He hospitably invited them to his house, which was at a little distance. There he introduced them to his wife and sisters. Lucy and her mother staid with these ladies, while Mr. Watson took Harry and his father to see his colliery. They were one by one to be let down in a bucket into the shaft of the coal mine, which was like a deep well. Mr. Watson turning his eyes upon Harry, asked his father if the boy would be afraid to go down. Harry, colouring highly, answered for himself, "No, sir, I am not afraid to go wherever my father goes."

His father went down first with one of

the colliers in the bucket, it was let down by the rope from a steam engine. In a few seconds Harry lost sight of him, and soon the bucket reappeared with only the collier in it.

"Now you may go down or not, just as you will," said Mr. Watson.

"I will go down," said Harry.

"Then do not be in a hurry. Let me put you into the bucket."

He took him by the arm, and lifted him in, and the collier bid him be quite still, and he was so. The bucket was let down, and it grew darker and darker as they descended, till at last he could see only a little speck at the opening at top, like a star of light. He could but just distinguish the man's hand and arm, like a shadow, as he pushed against the sides of the shaft, to keep the bucket from striking. They landed safely at the bottom, where there was lamp-light, and Harry sprung out of the bucket, with the assistance of his father's hand, and he was very glad that he had had the

courage to go down. As soon as Mr. Watson had descended and joined them, he took them through the galleries and passages of the coal mines, and showed Harry where and how the men were at work. Harry was surprised to see the numbers of workmen, and of carriages that were conveying the coal. And here he had the pleasure of seeing what he had long wished for, the manner in which a steam engine was employed in pumping out the water that collects in a mine. Before steam engines had been brought into general use, the master told him, that it was the labour of years to do what is now perhaps done in a few days.

His father stopped to look at a kind of lamp, which has been used for some time in lighting mines; and which, from its peculiar construction, is called the *safety lamp*, as it completely prevents the fatal accidents that formerly occurred from the explosion of inflammable vapours, when ignited by the unprotected flame of a candle. Harry wished to understand it, but his father told him he would

explain it to him at another opportunity that they must not delay now, for Mr. Watson's time was precious; which Mr. Watson did not deny. However, he did not hurry them, he only spoke shortly, passed on quickly, and called to the man at the windlass to "Let down." They were drawn up in the same manner by which they had descended, and Harry was glad to see the daylight again, though it dazzled him, and to feel the fresh air. Next they saw the iron rail roads, on which small carts, loaded with coal, were easily pushed along by one man, sometimes by one child guiding or following them; and presently they came to what Mr. Watson called "the inclined plane." Harry saw two roads of railway, placed beside each other up and down a steep slope. On one of them there were several empty coal carts linked together; and on the other, a cart loaded with coal, which, as it ran down the slope, dragged the empty carts up. This was effected by means of a chain, which was fastened by one end to the loaded cart, and by the other to the empty carts, and which

passed round a large pulley at the top of the slope or inclined plane; so that the loaded cart, descending by its own weight on one road, made those on the other road ascend.

“Little man, you may take a ride up and down if you will,” said Mr. Watson: “safe enough, and I see you are no flincher, and not bred too daintily to sit in a coal cart, a slave to a coat or a jacket.”

Harry jumped upon one of the empty carts.

“Throw him a truss of that hay to sit on. There, hold fast now for your life. Keep an eye on him. Up with you.”

And up he went, and from the top looked down upon his father, and for a moment he felt afraid to go back again, it looked so steep. A collier's boy, who was standing by grinning, told him he went “up and down the same way ever so many times a day, and no harm never.” Harry said to himself, “If it does not hurt others, why should it hurt me?” And thus, conquering his fear by his reason, he took his seat, and down he went.

“Father,” cried Harry, as soon as he

had one leg out of the cart, "I am glad Lucy was not with us. She would have been frightened out of her wits at seeing me coming down."

"Look to yourself now, and take your other leg out of the cart," said Mr. Watson, "for we want the cart to go up again."

"It was lucky I drew my leg out of the way in time, or I should have been thrown out of the cart along with that mountain of coal," said Harry.

"Yes, people must take care of their own legs and arms in these places," said Mr. Watson; "and in all places it is no bad thing to do."

Bluff and rough as he was, Harry liked Mr. Watson, who was very good-natured, and whenever he had time to think of the boy, pointed out what was worth his seeing; but once nearly threw him into a ditch, by swinging him too far with one arm over a stile. At the next stile Harry said,

"I would rather get over by myself, sir, if you please."

"Do so if you can; and I see that you

can, so I need not trouble myself more about you."

It was dinner time when they reached Mr. Watson's house. Here they dined at an earlier hour than Harry and Lucy were used to, but they were quite ready to eat; Harry especially, after all the exercise he had taken. The dinner was plentiful though plain, and there were creams and sweet things in abundance, for the master loved them, and his wife and sisters were skilled in confectionary arts. As soon as the cloth was removed, Mr. Watson swallowed a glass of wine, and pushing the bottle to his guests, rose from table, saying, "I must leave you now to take care of yourselves, I must go to my business."

Harry jumped up directly, and followed him to the door. His mother called him back, saying, she was afraid he would be troublesome. "Mr. Watson did not ask you to go with him, did he?"

"I did not think of the boy," said Mr. Watson, looking back from the door. "I am going only to see my workmen paid

this Saturday evening; this would be no diversion to you, my boy, would it?"

"Yes it would," said Harry, "if I should not be troublesome," he was going to say, but Mr. Watson went on,

"Follow then, and welcome. You will not be any trouble to me: I shall not think of you more than if you were not with me."

So much the better, thought Harry, who liked to stand by, and see and hear, without any body's minding him. Mr. Watson hastily swinging round his great coat as he spoke, flung the flaps into Harry's eyes; but Harry not minding that, ran after him; Mr. Watson strode across the court yard, and up the office stairs, three steps at a time. The room was full of men, who made way directly for their master, but the crowd closed again before Harry could pass. However, he squeezed in under the elbows of the great men, till he got to a corner beside the desk of the clerk, who was sitting with a great open book, and a bag of money before him. Harry knew he was

not to interrupt, so he asked no questions, but got up on a tall mushroom-topped leather stool, which stood beside the clerk's seat, and watched all that went on. He was amused with the countenances of the men, who each in turn came to the desk. He observed that Mr. Watson was in the first place very exact to see that they were rightly paid. Once when there was some difficulty, with a deaf stupid old man, about the *balance* of his account, he looked into the books himself, to see whether the old man or the clerk was right; and Harry, looking and listening, tried to learn what was meant by this *balance of account*. Mr. Watson was better than his word, for he found time between the going away of one class of workmen, and the coming of another, to explain it to Harry, whom he saw poring over the clerk's shoulder, and who once ventured to say, "Where is the *balance* that he is talking of?"

"Look here, the whole mystery is this. Look at the top of these pages, and of all

the pages in the book. D^r. and C^r., that is, *Debtor* and *Creditor*. Debtor on the left hand page; Creditor on the right hand page. All that this man owes to *me* is put on the Debtor, or left hand side of the book; all that is due to *him* is to be put on the Creditor, or right hand side. Then add together all the sums, that belong to the Debtor side, and all the sums that belong to the Creditor side, and see which is the *heaviest*, or largest, and deduct the least, or *lightest* sum from it; the difference, whatever it may be, is called the *balance*. You may consider an account as a pair of scales, and the sums put on either side as weights: the two sides are at last to be made to balance each other, as the weights in the opposite scales. Now, for example, look here, at John Smith's account, Debtor side two pounds. Creditor side four pounds eight shillings; you, my boy, may make out what the balance is, which I am to pay him. Write your answer down, when you know it. But take your head

out of my way. I must go on with my business."

Harry wrote his answer with a pencil, and put it on the desk before Mr. Watson, but it was long before it was seen, or thought of.

"Two pounds eight shillings is the balance due to John Smith."

"Right," said Mr. Watson. "The same method is observed in keeping all accounts; the money paid by the person who keeps the account is put on the Debtor side, and the money received by him on the Creditor side."

"Is that all?" said Harry.

"All in simple accounts," said Mr. Watson. "But *book-keeping*, though on the same principle, is much more complicated."

Harry was interested in listening to what was said to the people: Mr. Watson inquired how they were going on at home, and they told him all about their wants, and their hopes, and their fears.

Several of the workmen left part of their money in his hands, to be put into the *Savings bank*. Harry understood

that by so doing the men obtained a provision for the time when they might be sick, or must grow old. There was one slovenly man in rags, ill-patched: when he came up to be paid, Mr. Watson looked displeased, and said, "What a shame, Giles, to see you in such rags, when you earn so much? If you would put less of your money into your cup, you would have more on your back."

Harry understood what he meant, the ragged man walked away ashamed, while his companions laughed at him. Mr. Watson was steady as well as good-natured to the people. The industrious and frugal he encouraged, the idle and drunken he reproved, and he took pains to see that justice was done to them all.

WHILE Harry had been seeing these workmen paid, and learning what is meant by the balance of an account; Lucy had been learning something, equally interesting to her, concerning

sugar-plums, and sugar-candy : one of Mr. Watson's sisters was well informed both in the practice and theory of confectionary. As soon as Harry came in, Lucy ran to him, to tell him what she was intent upon ; and he was obliged, for the present, to keep his debtor and creditor accounts to himself.

“ Harry, my dear ! you know those little, tiny sugar-plums, which are no larger than the head of a minnikin pin.”

“ I think I know the sugar-plums you mean,” said Harry ; “ but I do not know a minnikin pin, nor the size of its head.”

“ Then never mind,” said Lucy ; “ I forgot that you, being a man, could not know minnikin pins as well as I do. But as to the sugar-plums, you saw some this very day at dinner on the top of the trifle.”

“ I remember,” said Harry. “ Well.”

“ Well, my dear Harry, you can have no idea what hard work it is to make those little comfits. Miss Watson was telling me how she made ginger sugar ; and afterwards I asked her, if she could

tell me, or show me, how those little sugar-plums are made. She said, that she could not show me, for that she could not make them herself, not being able to bear the heat, in which they must be made. She told me, that the pan in which they are boiled must be set over a great fire, and that the sugar of which they are made must be stirred continually in that heat. A man with a long-handled shovel keeps stirring, stirring, stirring; and sometimes strong men faint in doing this."

Harry wondered, that some way of stirring the sugar in these pans by machinery had not been contrived, and he was going to question Lucy farther upon the subject, but she was in a great hurry to go on to sugar-candy.

"Harry, do you know how sugar-candy is made? I will tell you, for I have just learned. When sugar is dissolved, it is poured into pots, across which sometimes thin rods, and sometimes threads, at a little distance from

each other, are stretched. These moulds, and the liquid sugar in them, must all be covered up, and kept in a great heat, for a certain time, and nobody must disturb them. They are placed in a room, which is one great stove; care is taken that no wind should be admitted, for they say that the least disturbance spoils the whole, and prevents the sugar from forming into those regular-shaped crystals, which you have seen in sugar-candy. If the vessels are not disturbed, they form on the little rods I mentioned to you, or on the strings. I dare say you remember often finding strings in sugar-candy; and now we understand the use of them."

"But what do you mean by crystals?" said Harry. "Will you explain?"

"I remember I once thought," said Lucy, "that crystals meant only bits of that white substance which looks like glass. But Miss Watson has explained to me, that there are crystals of various sorts and substances, of sugar for instance,

and sugar-candy, and of I do not know how many kinds of salts; in short, of all substances that can be crystallised: those were her words, as well as I can remember."

"Very likely," said Harry; "but still I do not know exactly, what is meant by what you call crystallising."

"Turning into crystals," said Lucy. "What more would you have. Here is what they call a crystal of sugar-candy. Here are its regular sides: crystals, you know, have always regular sides, and a regular number of them. Look at it, and touch it, and taste it if you will."

Harry looked, and touched, and tasted; but still not quite satisfied, he said, "I want to know, what difference there is in things, before and after what you call crystallisation."

"The difference in this *thing* is very plain," said Lucy. "Before it was crystallised it was syrup, that is, sugar and water; and now you see it has become solid."

“Very well, so far I understand,” said Harry, “but how or why do fluids crystallise?”

Lucy did not know, she confessed, and was well satisfied to let the matter rest there for the present. Some time afterwards, she took notice of an ornament on the chimney-piece; a small basket, which looked as if it were composed of crystals of glass, or of white spar.

Miss Watson told her, that it was not made either of glass, or spar. “I made it,” said she.

“You made it! How could you make it,” said Lucy. “And of what is it made? It looks something like white sugar-candy; perhaps it is made in the same way; perhaps it is a sort of sugar-candy.”

“The taste would soon decide that,” said Harry. “May I just try the experiment with the tip of my tongue.”

Miss Watson gave him leave to taste it; but she warned him, that he might perhaps not like the taste.

“Then I guess what it is,” said Harry. After having applied the tip of his tongue to one of the crystals, he added, “By the taste, I am sure it is alum.”

It was alum. Lucy had seen large pieces of alum; but none large enough to be hollowed out into a basket of such a size, and it would have been difficult to have carved it into such regular shapes. She recurred to her first idea of the resemblance to sugar-candy, and she continued to think that it was made by the same means. Miss Watson told her, that she was so far right in her guess, that it was made in the same manner as sugar-candy, that is, by crystallisation. She showed her the whole process, which is very simple. In the first place, she put some water into an earthen pipkin, with as much alum as could be dissolved in that quantity of water. She boiled it till the alum was dissolved. By these means, she told Lucy that she had obtained a *saturated solution* of alum, that is, that as much of the alum had been dissolved as the water

could hold. Then Miss Watson took a little wicker basket, and suspended it by its handle on a stick laid across the mouth of the pipkin; so that the basket, handle and all, were totally immersed in the dissolved alum. The basket did not touch the bottom of the pipkin. As it was very light, it would not have sunk in the water, had not a little weight been put into it. The whole was then covered with a coarse cotton cloth, and put aside in a cool place, where it was not likely to be disturbed. She advised Lucy to let it alone during a day and night, to give time for the crystallisation to go on slowly, so as to form perfect crystals, which can be obtained only by the slow and regular evaporation of the water.

There still seemed to be some difficulty in Lucy's mind, after she had heard this, and looking at Harry, she said,

"I know what you are thinking of, Harry, and I am thinking of the same thing; that I wish I knew exactly what is meant by *crystallisation*."

“That was what I was thinking of,” said Harry, “and I was wishing that I could get at a book which we have at home, in which I know that there is an explanation of it.”

Miss Watson asked if the book was *Conversations on Chemistry*.

“The very book! how quickly you guessed it. And you have it! how very lucky!” said Lucy, as Miss Watson took the book from her book-case. She found for Harry the passage that he wanted. It begins with Emily’s saying,

“*I do not quite understand the meaning of the word crystallisation*.*”

“That is exactly what I felt,” said Harry.

“And what I ought to have felt,” said Lucy. “But I really did not know that I did not understand it, till you asked me to explain it, Harry. Now let us read on.”

After reading a few lines she came to

* *Conversations on Chemistry*, vol. i, p. 341; eighth edition.

the word *caloric*, and asked if caloric meant the same as heat.

"Not exactly," Miss Watson said; "in this book the difference is defined."

She turned to another part of the book, and showed Lucy the passage which defines the difference between heat and caloric*. The subject was new to Lucy, and almost at every line she wanted explanations. She stopped, and whispered to Harry, that she was not sure she knew what was meant by "*the integral parts of a body*." Miss Watson turned to the beginning of the volume, and showed her a perfectly clear explanation of *integral parts*†.

"How well you know all this!" said Lucy. "You know where to find every thing in this book."

Miss Watson said that was not surprising, for that she had read it more than once.

* Conversations on Chemistry, vol. i, p. 35; eighth edition.

† Ibid. p. 9.

"The first time you read it did you find it difficult?" said Lucy.

No, she said, she had not found it difficult, but very easy and clear.

"Ah! because you did not read it till you were grown up, I suppose?" said Lucy.

Miss Watson said that she did not think this was the reason, as she had seen readers not older than Lucy understand it perfectly well.

"It is very odd then," said Lucy, "that I am obliged to stop, you see, two or three times, before I have read a single page, to ask the meaning of the words."

"Because you have begun in the middle; you have not read the book from the beginning," said Miss Watson; "or else you would have found all the terms explained as you went on."

"But even so, I am afraid I should have forgotten them," said Lucy, sighing. "You must have a very good memory to remember them all."

Miss Watson said, that besides having read the book from the beginning, she had

often looked back to the definitions of the words, and to the explanations, whenever she found herself not clear as to what was meant.

The conversation afterwards turned upon different subjects, in which Lucy had no concern ; therefore she followed Harry, who took the Conversations on Chemistry to a comfortable nook in the room, where he could be quiet, and, after his slow but sure manner, he made himself understand thoroughly what he was reading. Lucy read more quickly, and when her mother and Miss Watson were passing by them, she caught hold of the skirt of her mother's gown, and said,

“ I understand this passage about crystallisation now, mamma, I think ; it is very clear.”

“ I do not in the least doubt that *it* is very clear, my dear,” said her mother, “ but are *you* very clear ?”

“ Here, mamma, if you will just look at the book, at this passage, mamma, which begins, ‘ Crystallisation is simply —’ ”

“ I do not want to read it, my dear,” said her mother, “ or to hear you read it, but tell me the sense of it in your own words.”

“ But, mamma, though I do understand it,” said Lucy, “ you know it is impossible that I could put it in such good words.”

“ I am well aware of that, Lucy,” said her mother ; “ but explain it in any words that will express what you mean ; then you will be certain of what you know, or do not know.”

“ Well, mamma, in the first place, suppose a body, that is, a substance —”

“ What kind of a body ? what kind of a substance ?” said her mother.

“ It must be a fluid,” said Lucy. “ Yes, mamma, before it can be crystallised, it must be a fluid. Therefore begin by supposing a fluid. No, I believe, that first of all, before it becomes fluid, the body should be a solid. Hey, Harry ? Which shall I tell mamma to suppose, a fluid or a solid ?”

“ Settle it for yourself, Lucy, my dear,”

said her mother. "It cannot depend upon what Harry thinks, but upon what really is the fact."

"I recollect it all now, mamma," said Lucy, after a short pause, "and I will begin again with a solid body, mamma; suppose a solid body, sugar, for instance, or alum, mamma, is dissolved, either by heat or by water; and suppose that none of its *original* parts, that is the parts of which it was originally composed, are lost by being dissolved, but only separated, as it were, by the water, or by the heat by which they are dissolved. Then, mamma, if you could again take away the heat, or the water, the original parts of the substance, the alum, for instance, would come together again, and adhere, when what separated them is gone. This is crystallisation. You may take away the heat by cooling it, and then the first parts come together again in a solid form. Or you may evaporate the water, which separated the parts, by heat; and then they will come together again, crystallised.

Whatever way you do it, whether by heat or cold, if it is not disturbed, but allowed to go into its regular forms, it is called crystallisation."

"You have laboured through your explanation, Lucy, tolerably well," said her mother.

"But there is one other thing more you should say, Lucy," said Harry.

"Say it for me," said Lucy.

"That different substances form into crystals of different shapes. Crystals of substances of different sorts, as I have just been learning," continued Harry, "have always a certain regular number of sides; so that when you see the crystal, after counting the sides, you can tell of what it is composed; or you can tell beforehand the number of sides and the shape of the crystals that will be formed from any known salt or substance, which you have dissolved, and left to crystallise."

"For instance, alum," cried Lucy. "The alum which was dissolved in the hot water, and which Miss Watson has left there to

crystallise, we know, will be in the same shaped crystals as these in this first basket. I will count, and tell you the number of sides."

Harry said, he thought that Miss Watson could, if she pleased, tell the number of sides without counting them, and so she did.

"How difficult it must be," said Lucy, "to get by heart, and to keep in the memory the number of sides which belong to all the different kinds of crystals!"

"You need not do that," said Miss Watson. "Lists of them are to be found in many books, to which you can refer when you want them."

"But you knew alum without looking at any book," said Lucy.

"Yes, because I had been accustomed to see its crystals," said Miss Watson.

"As I told you before, many of the facts in chemistry or mineralogy, which it would be difficult to remember separately, or merely from having read or heard an ac-

count of them, are easily fixed in the mind, by trying experiments, and by connecting those facts with others.

Miss Watson told Lucy that she had become particularly fond of this study, because her father was a chemist, and she had often been in his laboratory while he was at work. "Unless I had seen the actual things I should not have remembered the descriptions of them, I am sure," said she; "and besides, I was so much interested in my father's experiments, and so curious to know whether they would turn out as he had previously expected, that the whole was fixed in my memory. Unless I had had somebody with whose pursuits I could sympathise, and in whose discoveries I felt an interest, I should soon have forgotten even the little I had learned."

"But does not it make you happy?" Lucy asked.

"Are you, or are you not happier than if you had not this pursuit?" said Harry.

Miss Watson smiled at the earnestness with which they questioned her ; and answered, that she thought she was much happier for having this taste, and this occupation. She said it never prevented her from doing other things, which were more necessary. To this her brother added his testimony.

“ Her being something of a chemist has not spoiled her hand for being a good confectioner,” said he. “ On the contrary, it has improved it, for she knows the reasons for what she is doing. All confectioners and cooks must be chemists for so much, but they do not know the reasons why they succeed one time, and fail another. With them it is all knack, and hap-hazard, or what we call *practice*, at best. Now,” continued Mr. Watson, “ here is an old receipt book, which belonged to the great-grandmother of a noble family, famous in her day, no doubt, for her cakes, and puddings, and confectionaries, and cures for all manner of sprains, and aches, and

bruises: look at any of these, and you will see what nonsense half of them are. How many useless ingredients are put into the receipt, either on purpose to puzzle other people, or from ignorance, and a sort of superstitious belief, that there was a *mystery* in doing these things."

Harry and Lucy amused themselves by looking at some of these old receipts, which, however, were hard to decipher, the ink being yellow, and the spelling old and incorrect.

The next day was Sunday. Harry and Lucy went with their father and mother, and Mr. Watson and his family to church. The church was in the village near the house. As they were walking home, Mr. Watson asked if they would like to see some of the houses in the village, where his workmen lived, and the cottages in the neighbourhood. Harry and Lucy were glad to take this walk, and Harry kept close to Mr. Watson wherever he went.

In one cottage, the master of the house,

a great fat man, was sitting at his dinner. Hot roasted duck and cauliflowers were on the table before him; while his wife, a pale, starved-looking soul, was standing behind his chair, waiting upon him, and his children were huddled together in a corner, at a distance. He never let any of them eat with him. He laid down his knife and fork, as the company came in, trying, as much as he could, to soften his sulky look. Mr. Watson spoke kindly to his wife and children, but took no notice of the man. As he went out of the house he said, loud enough for him to hear,

“I should have no appetite for my roast duck, if I were forced to eat it by myself, without my good wife to take a share.”

Lucy wondered that Mr. Watson did not insist upon the husband's letting the wife and the poor children sit down with him.

But Mr. Watson replied, “that he had no right to do this; every man had liberty to do as he pleased in his own house, and in his own affairs. He could not interfere

between man and wife farther than he had done, by laughing at the surly husband, and shaming him before company." He said he had known this man buy, for his own eating, the first green peas of the season, when they were expensive rarities; even when his children had not clothes to cover them.

"The selfish creature!" said Lucy.

"The brute!" said Harry.

In the evening, as they were walking in a pretty lane, near Mr. Watson's house, they met a man, who was endeavouring to come up the lane; but he could not, by any efforts he could make, walk in a straight line; he was so much intoxicated, that he scarcely knew what he was doing. When he met Mr. Watson he started, stammered, tried to take off his hat, and to stand out of the way, but he could not accomplish it. Lucy was very much shocked. Mr. Watson called at his clerk's house, and ordered that this man, John Giles, should be struck off the list of workmen, and should not be

admitted to the foundery for the next week; and that Markham, who was a sober fellow, should come in his place.

Harry thought this was very right, till, some time afterwards, when the drunken man's wife came to Mr. Watson, to beg him to pardon her husband, and to readmit him to the work. She said that if he did not she and her children must suffer for it, that her husband would beat her, and only drink the more if he was vexed. The tears rolled down her face as she finished speaking. Harry wondered how Mr. Watson could refuse her, for it was not her fault that her husband was drunken.

At night, when Harry was in his father's room, he talked to him about this, and asked whether he thought Mr. Watson was right or wrong. Right, his father said; he did not think his refusal was hard-hearted, but steady; because it was his duty to do what was just for a great number of people, as well as for this one man. If he were to employ a drunken workman

in preference to a sober man, this would encourage the drunken, and be unjust to the sober.

“ I would not encourage the drunken and idle upon any account,” said Harry. “ I thought Mr. Watson was quite right at first, in ordering that he should not be admitted to the works for a week. But might not Mr. Watson have forgiven him for the sake of the woman ?”

“ Then any other workman might drink, and might hope that his wife would beg him off, and obtain his pardon,” said Harry’s father.

“ Father,” said Harry, after a long silence, and looking very serious, “ I thought that a great mechanic was only a person who invented machines, and kept them going, to earn money, and to make things cheaply. But now I perceive that there is a great deal more to be done ; and if ever I grow up to be a man, and have to manage any great works, I hope I shall be as good to my workmen as Mr. Watson is. I will



be as just and steady too if I can. But, father, I see it is not so very easy to be just, as I should have thought it was. There is a great deal to be considered, as I find from all you say about forgiving or not forgiving the drunken man for his wife's sake. I feel that I have much more than I knew of before to learn."

"Harry, I wish you would go to bed, and to sleep," said his mother; "for I am sure you must be tired after all you have seen, and heard, and thought, this day."

"Not in the least, mother. I never was wider awake," said Harry. "However, I will go to bed to please you."

Our travellers were to set out before breakfast, and very early in the morning. The family promised that they would not get up to see them off, lest they should delay them on their journey. Lucy did not forget to inquire for the alum basket, when she wished Miss Watson good night, and good-bye.

"If it has succeeded you will see it in

the hall as you pass through in the morning," said Miss Watson; "but yesterday one of the servants shook the vessel containing it, and by that means prevented the crystals from forming rightly. I was forced to begin the whole operation again. This time I locked the door to secure its being undisturbed."

As soon as she was dressed in the morning, Lucy ran down to the hall to see whether the basket was there. And there it was, standing beside her bonnet. The wicker skeleton was no longer visible; every part of it, handle and all, being covered with crystals of alum, apparently perfectly formed. She did not, however, stay to examine exactly, or to count their sides, which is always a tedious business; but seeing a note directed to herself, tied to the handle, she tore it open immediately. It told her that this basket was hers if she liked it.

"*If!* to be sure I do!" said she.

Miss Watson suggested, that if Lucy

should ever attempt to make such a one, she might put into the solution of alum a little gamboge, which would give to the crystals a pretty yellow tint; or she might mix with it any other colour she preferred.

Within the basket, nicely placed, Lucy found several little paper cornucopias, filled with sugar-plums, and rose, and lemon, and barberry drops, with receipts for making each, written within the papers in which they were contained.

She was so much delighted with her cornucopias, and their sweet contents, and with the pretty crystallised alum basket, and with the good-natured maker and giver of these good things, that she could think of nothing else, during the first hour of the morning's journey.

"Now, mamma, will you taste the barberry drops? Excellent, are not they? and the lemon, better still! Oh, mamma, cannot you taste any more? here are seven other kinds."

Before breakfast it was impossible to taste all the seven, even to oblige Lucy, and in honour of Miss Watson. But Harry was an indefatigable taster. He went on without resistance, but without giving what Lucy deemed sufficient tribute of praise to each. At last, when much urged by the repetition of, "Is not it excellent, Harry?"

He confessed, that the tastes of different drops were now all so mixed in his mouth, that he could not tell one from the other. Lucy shut up her cornucopias, and reserved her plenty for time of need. "But, mamma," said she, "when all these are gone, now that I have the receipts, I can make the same whenever I please."

"It is not quite certain," her mother said, "that because you have the receipts you can make others equally good, whenever you please."

Piqued a little by this observation, and by a smile of Harry's, Lucy began to form

various schemes of trying experiments, in making rose and barberry drops, and sweetmeats, like those which she had tasted of Miss Watson's, and which every body had liked. She enumerated such numbers of things, which she intended to make, that Harry at last laughed, and said,

“My dear, you will then turn cook and confectioner quite, and forget every thing else.”

Her mother observed, that it was useful to know how these things should be done ; but that the propriety of making, or not making them ourselves, depends upon the circumstances in which we are placed, and on our rank of life. Those who have servants, that can make them, would act foolishly in wasting on such work their own time, which they may employ more advantageously. Miss Watson, who perhaps had no servants, that could make these things, did wisely and kindly, in making them herself for her friends who like

them; and it was particularly obliging and amiable of her to condescend to do so, because she has other pursuits, and a cultivated understanding. Lucy's mother told her, that if she persevered in her wish to learn how these things were made, she should, at the proper season of the year, see and assist the housekeeper in making sweetmeats. This satisfied her. And she was at leisure to listen to Harry, who, for his part, was anxious to become a chemist, and who had been struck with the idea of the happiness of the person, who possessed a laboratory, and could try chemical experiments. His father told him, that it was not necessary to have a laboratory and a great apparatus for this purpose, as one of the most ingenious and successful of chemists and philosophers has observed. Many most useful and excellent experiments can be tried in an easy and simple manner.

Here his father was interrupted by an exclamation from Lucy, at the sight of a

tall finger post, on one of the arms of which she observed, To BIRMINGHAM.

Harry and Lucy anxiously watched to see whether the driver turned down this road, as they had both an ardent desire to go to Birmingham to see some of the manufactures, of which they had heard most interesting accounts. Lucy's astonishment had been excited by some scissars which Mr. Frankland had shown her, which she had tried, and which, though not of the most beautiful polish, cut sufficiently well for all common purposes, and yet, oh, wonderful! Mr. Frankland told her, that this pair was one of a dozen which he had bought for one shilling!

Harry's curiosity had been raised by hearing of a knife with five hundred blades, which he had been told was to be seen at Birmingham.

The knife came first to his recollection; an instant afterwards, however, he said, "But there are things there, a thousand times better worth seeing than that."

"Oh father!" cried he, turning to his father, "I hope we shall go to Birmingham, that we may see the grand works at Soho, Mr. Boulton's. I read an account of them while we were at Mr. Frankland's, in one of the notes to that Botanic Garden, when you were looking for the Barberini vase, Lucy. It said, that there is a magnificent apparatus for coining, all worked by one steam engine, which cuts halfpence out of sheets of copper, and at one stroke stamps both the faces and edge of the money."

"Yes, I remember your reading it to me," said Lucy; "and it was said, that four boys of ten or twelve years old, no bigger, mamma, than Harry, could, by the help of this machinery, worked by that great giant enchanter, the steam engine, make—how many guineas do you think, in one hour? thirty thousand, mamma. Was not it, Harry?"

"Yes, thirty thousand," repeated Harry; "and besides this, it is said

that the machine keeps an exact account."

"An *unerring* account was the very word," said Lucy. "It keeps an unerring account of all the money it coins. Papa, I do hope you are going to Birmingham. Oh! mamma, I hope we shall see all that was described in those lines, do you recollect? I hope we may see,"

"Hard dies of steel the cupreous circles cramp,
And with quick fall the massy hammers stamp."

Her father told her, that he believed that these massy hammers are no longer at work at Soho; but that a far more magnificent apparatus for coining is now established at the Mint in London. He hoped, he said, to show them all these wonders of mechanism, of which they had read in prose, and poetry, at some future time. For the present, however, he must disappoint them. He could not go to Birmingham, he must pursue the road to Bristol. Even on their account, he

added, addressing himself to their mother, he did not choose now to go to Birmingham. The general principles of a few great inventions, he hoped, had been clearly understood, and fixed in their minds, by what they had already seen. He was glad to find that they had taken pleasure in following the history of the progress and consequences of those noble discoveries; he would therefore take care not to confuse their minds, by showing them the details of small ingenious contrivances, in the Birmingham workshops and manufactories, or by dazzling their eyes with the sight of more than Arabian Tale magnificence, in the show-rooms of "the great toy-shop of Europe."

Harry and Lucy had not been so much spoiled by their father's and mother's indulgence, that they could not bear disappointment. One sigh Lucy was heard to give for the *great toy-shop of Europe*. Harry suppressed his rising sigh; for since

the steam engine coiner was not to be seen, he cared little for the rest. They both agreed "that papa knew best."

And this was not with them a mere phrase, said with a look of hypocrisy, but with honest faces and hearts, and firm belief from experience, of the truth of what they said.

"WHAT is the name of the town to which we are to come next, mamma?" said Lucy.

"Bridgenorth, my dear."

"Bridgenorth!" repeated Lucy; "I am sure there is something I have heard about Bridgenorth; but I cannot remember what it is."

"I know what it is, I believe," said Harry; "a famous leaning tower."

"Yes," said Lucy, "that is the very thing! I recollect reading about it, in my History of England, which said, that this tower of Bridgenorth was not always

leaning: formerly, a great while ago, it was upright and like any other tower, but it was shaken from the foundation when it was bombarded, during some siege in the time of the civil wars, was not it, mamma? I read it to you: and it has hung over in the same leaning state ever since, looking as if it would fall, and yet not falling. I am glad we are to pass through Bridgenorth, that we may see it with our own eyes."

"Yes, I shall like very much to see it," said Harry.

Their father desired the postillion to drive slowly when he came into the town, and Harry and Lucy's heads were first out of one window, and then out of the other, eager for the first sight of the hanging tower.

"There it is!" cried Harry.

"Of red brick!" said Lucy. "I see it. I had fancied that it was of grey old stone. I expected to see a fine venerable ivy mantled tower."

"I cannot help it," said Harry; "but, my dear, take your head out of my way, for I cannot see what I want to see."

"There you may have it all to yourself, my dear Harry," said Lucy. "I think it is very ugly."

"Nobody ever said it was pretty, did they?" said Harry; "but it is a curious thing."

"Not nearly so curious as I expected," said Lucy. "Not nearly so dangerous looking as I fancied it must be. I had hoped that it would quite take away my breath to look at it, and that we could not drive by without fearing, that it would fall upon our heads."

Harry had no such fears or hopes, because he recollected distinctly having read an account of it. He knew, that at Pisa there is a tower which overhangs 14 feet, much more than this of Bridgenorth. His father asked him, if he could tell why these sloping towers continue to stand. "What prevents them from falling, Harry, do you know?"

Harry said he believed he knew, because he had read in Scientific Dialogues an account of them, and an explanation of the principle on which they stand.

"I know you did," said his father, "and you understood it at the time you read it: but let me see if you understand it now."

"Father, it is very difficult to express it in words, as Lucy says; but if I had my little bricks, I could easily show the thing to you."

"Yes," said Lucy. "Very often we built towers, which leaned over, and yet stood; and we used to try how much we could venture to make them overhang without their falling: I recollect that perfectly, though I do not know the reason why they did not fall."

"If I had the little bricks, I could show and explain it," said Harry.

"But as you have them not, and as you cannot always carry a *hod* of little bricks about with you, Harry," said his father; "try what you can do to explain yourself

by words, those you may always have at command."

"*May*— I wish I had," said Harry.

"Begin, Harry, by thinking of what you wish to express, till you are quite clear that you know what you mean, and depend upon it you will then easily find words," said his father. "People often imagine that their difficulty is in finding words, when the real difficulty is in having clear ideas of things."

"Then you must, if you please, father, give me time," said Harry.

"As much time as you please," said his father; "and that I may not hurry you, I will go on reading this book."

"Thank you, father," said Lucy for Harry.

Harry looked back at the hanging tower, which was yet in view, and after he had thought till he was clear of what he meant to say, without considering about the words, which came when he began to speak, he went on fluently, after the first word, "fa-

ther," had made his father look up and lay aside his book.

"Suppose that a plumb-line was let down from the centre of gravity of the whole mass of that leaning tower, the bob of the plumb-line would fall within the base, or foundations: the plumb-line could not hang outside of the base, or else the tower must tumble down. As long as the centre of gravity is supported, any part may lean over, or may hang out of the perpendicular line, and yet, provided the materials stick together, the tower will not fall."

"I think I understand that," said Lucy, "but I am not quite clear."

"If you do not understand what is meant by the *centre of gravity*," said her father, "you cannot be quite clear, indeed you cannot comprehend it at all."

Lucy said she remembered seeing Harry, when he was a little boy, standing upon her father's knees, and leaning his body so much to one side, that she was afraid he must have fallen. "And papa you then

explained to me how far he might have leaned over without any risk of tumbling down. You also told me something about the centre of gravity, but that I do not recollect, exactly."

"Remember how often," said Harry, "my father has shown us, that the motions of our *tumbler toy* depended on the situation of the centre of gravity. By the bye, there is a way of finding out where the centre of gravity is in a body, or figure of any shape."

"Is there?" said Lucy. "I do not remember papa's showing us that. How did you learn it? And if it is not very difficult, can you teach it to me? Who taught it to you?"

"A book," said Harry; "my own good 'Scientific Dialogues.' And if I had but a bit of card, and a bit of thread, and a pin, and a pencil, and if we were not in the carriage, I think I could show it to you now."

But as all these *ifs* stood in the way

the matter was put off for the present, and, like many good things that are put off, was forgotten. Nor can we much wonder that this was driven from the recollection even of the philosophic Harry, by the bustle he saw in the next town through which they passed. It happened that there was a great fair in this town, and it was filled with such crowds of people, and so many stalls and booths, covered with canvas, lined the streets, that it at first seemed impossible that way for their carriage and horses could be made through them, without trampling on some of the people, or overturning some of the tents. The postilion stopped, and called civilly to the people to make way : cloaks and great coats yielded on each side, and those in front got from under the horses' noses, as they advanced step by step. Lucy had let down the glasses, and was looking out with great interest, not unmixed with apprehension, and listening to the—

" Universal hubbub wild,

Of stanning sounds and voices all confused."

And as, little by little, the carriage made its way through the dense multitude, she saw many hair-breadth escapes, which made her shrink, and cry " Oh ! " and " Ah ! " many a time, for those who were all unheedful of their danger, in the ardour of bargaining, the pleasure of gossiping, the vehemence of scolding, the stupidity of staring, or the anxiety of maternal affection. Here was seen a mother crossing before the very pole of the carriage, which nearly ran into her ear, in so much haste was she to snatch out of the way two children, standing unconscious, the one with an apple, the other with a whistle in his mouth. And close to the wheel of the carriage, at one time, there was a young damsel, with pink cheeks, bargaining so earnestly for a pink ribbon with an old woman in her booth, that the wheel must, as Lucy thought, have gone over her outstretched foot, but that just in time looking

up, she drew it in, and still holding the dear ribbon in her hand, continued her bargaining. Next there was a group of old women, leaning on their sticks, with their bonnets close to each other, telling and listening to something so eagerly, that they never heard the carriage coming, till the wheel went over the point of one of their sticks, and begrimed the scarlet cloak of the speaker, before she would move her shoulder out of the way.

Then came an awkward clown on horseback, with elbows out, lugging at the hard mouth of his shag-maned colt, who knew no more than his rider the way he should go, but who, with glassy eyes starting out of his frightened head, seemed to have a mighty mind to run straight in at the carriage window. Seeing which, Lucy ducked directly. How they passed she knew not ; but when she looked up again they were gone, and Harry's body was far out of the window, watching the operations of man and horse,

There was the colt, floundering and struggling with his rider, at the corner of the street, where both vanished before it was settled which would be victorious.

But now Lucy saw before them, in a new street, a huge wooden house or caravan on wheels, on the outside of which in large letters were written the names of the wild beasts who lodged within, and who were all to be seen for the sum of one shilling. Across this part of the street hung flapping, furious portraits, coloured to the life, of a lion rampant, a hyena, a tiger, and a mountain cat with enormous whiskers.

Lucy began to be a little afraid that the *poor* horses would be very much frightened. But either they did not think the portraits striking likenesses, or they were not sufficiently acquainted with the originals and their private histories, to be as much afraid as Lucy thought they ought to be. They went by quite quietly, yet were, as Lucy

observed, most foolishly frightened soon afterwards, by a poor little boy popping out from under the long skirts of a puppet-show. One reared, the other *shyed*, but their driver being a temperate whip, patted them into good humour, and brought them on safely to the inn. Turning under the archway, they knew where they were, lowered their pricked-up ears, and stood perfectly still at the bar-door, neighing by turns to their acquaintance in the yard, who answered from their inmost stalls.

Lucy found, on the chimney piece of the room where they were to dine, an advertisement, informing the public, that—

“There is now in this town a new fairy, infinitely surpassing the old Corsican fairy, who appeared in England in the last century, and who was honoured with the approbation of the nobility and gentry. But the new fairy is full an inch less than the old fairy, and can speak three languages, French, English, and Italian, dances to

admiration, and waltzes inimitably, if required."

While Lucy was reading this card, Harry was perusing another, which he had found on the table, and which informed the public, that this evening, at six o'clock, a company of tumblers would, at the theatre in this town, exhibit, for the amusement of the public, several curious feats in tumbling and rope dancing. One man promised to carry a ladder poised on his chin; and another to balance a table on the rope, and even a chair on which he was himself to be seated with his bottle before him, and quite at his ease.

Harry was curious to see these sights: he told Lucy, that here would be fine examples of all they had been saying about the centre of gravity. These wonderful things must be done from understanding how to manage that properly. He wished more and more, the longer he thought of this, to see these tumblers. Lucy, it must be confessed, was not so curious on this

subject, and she would much rather, had she been to choose, see the new Corsican fairy.

Their father and mother had determined to sleep at the inn where they now were, and they told Harry and Lucy, that they would, in the evening, let them see either the Corsican fairy or the tumblers, but to both they could not take them, as they were in opposite parts of the town : the tumblers at the theatre, the Corsican fairy to be seen at the court house, between the acts of a concert. Lucy was fond of music, Harry did not care for it.

“ Well, Harry and Lucy, which do you choose ? ” said their father. “ Take five minutes to consider, but then you must decide, that we may engage our places or buy our tickets in time.”

Lucy recollected the resolution she had made, when first she set out upon this journey, that she would imitate her mother’s kindness, of which she had seen so many examples ; she therefore gave up gene-

rously her own wish to hear the concert and see the fairy ; she did this in so kind a manner, that she put her brother quite at ease. She was very happy with him seeing the tumblers, and when it was all over, she was quite content with them and with herself.

At the end of the next day's journey our travellers arrived at Clifton. Harry and Lucy were delighted with the place, and were glad to learn that they were to spend some days here, in order that their mother might rest herself. The next morning after their arrival they walked with their father on the Downs, from the top of which they looked down a steep cliff, and saw the river Avon below. They descended to the river, down the cliff, by a new road, which a number of workmen were then making. The workmen were breaking some hollow stones, which had fallen out of the bank by the side of the road. The hollows of these stones were lined with shining crystals. Lucy picked up

bits of this stone, and added them to the collection which she had made at Matlock. The stone that sparkled with crystals was called, she was told, Bristol stone, and the crystals themselves were called Bristol diamonds. Lucy afterwards saw, at the house of a lady in Clifton, a cross of these Bristol diamonds, and another cross of real diamonds, and on laying the two side by side she could scarcely tell the difference.

They had now descended to the bank of the river, where they stood some time to admire the cliff called St. Vincent's rock. They then walked to view an extensive quarry, where some miners were blasting the rocks with gunpowder. They inquired of the head workman to what use the stone was applied. He showed them some of it, which had been hewn into blocks, and was intended for paving the streets of Bath and Bristol. The chippings were not thrown away as useless; but were, after being broken very small, employed to mend the roads. The rock was limestone;

Harry saw some of it burning in a kiln, by which it was converted into white lime.

“The lime burnt at our kilns,” said their conductor, “is very much sought after in this neighbourhood, not only for building but also in these new sugar-houses.”

“Is lime used in sugar making?” said Harry.

“Oh! are there sugar-houses in England,” said Lucy. “I thought sugar came from the West Indies.”

“Yes, brown sugar does, but it is purified or refined after it comes to England,” said her father; “and at Bristol there are some large establishments for this purpose.”

They now continued their walk till they came to the Wet Docks of Bristol. The Wet Docks are a basin of water, formed by throwing flood-gates across the ancient bed of the Avon, the river itself being turned into an artificial channel. The water within the basin is prevented by the flood-gates from falling with the tide, so

that the ships are kept constantly afloat, even at low water.

Our party found the basin crowded with ships, from different parts of the world. They easily distinguished those arrived from the West Indies, by the hogsheads of raw sugar that the crews were hoisting out. Harry observed, in a warehouse, as he walked along, the parts of a machine, which his father told him belonged to a rolling-mill, which was to be sent to the West Indies for squeezing sugar canes, along with pans of iron and copper for boiling the juice.

They returned to Clifton, much delighted with all they had seen.

The following morning, at breakfast, as Lucy helped herself to sugar, she asked her mother if she knew that there were sugar manufactories at Bristol ; and, added she, " Papa told us yesterday, mamma, that perhaps he would take us to see them."

" Yes, my dear, and he has just obtained

permission for you to see them this morning," said her mother.

"Are we to go there to-day? — Delightful!"

"But before we go, my dear children," said their father, "I should like to hear whether you already know any thing about sugar making."

Harry and Lucy said that they had read, in 'Edwards's West Indies,' an account of the sugar plantations in Jamaica, of the sugar canes and sugar mills. Lucy recollected that the sugar cane is a sort of straw-coloured jointed reed, about the thickness of the handle of an umbrella; that it grows in general to about the height of a man, and has at its top leaves like flags; that the canes are cut in autumn, and that the sugar-making time is a season of gladness and festivity to man and beast, especially to the poor negroes who work in the plantations.

Here Lucy was near going off far away from sugar-making to talk of the poor

negroes, but her father called her back again, by the question of, "What is to be done to the sugar canes after they are cut?"

"They are tied in small bundles," said Lucy, "and carried to the mill, where the sugar juice is to be squeezed out of them." Lucy looked to Harry for assistance when she came to the mill.

"It consists," said Harry, "of three large iron rollers, turned by wind, or water, or horses, or oxen, or perhaps now the people may have learned to work them with steam. The bundles of cane are passed between the rollers, and squeezed again and again, till all the juice is pressed out. It is caught in a wooden gutter, which carries it into the house where it is to be boiled. It is said to be of great consequence to boil it as quickly as possible; but I do not know the reason."

"The reason is, lest it should ferment," said her father.

"Ferment, papa! I know from old dear

‘Conversations on Chemistry’ what fermenting is; besides I have seen beer fermenting. But what harm does fermenting do to sugar?”

“When it ferments it ceases to be sugar. Do you know for what purpose it is boiled, Lucy?”

“That the water which is in the juice may evaporate,” replied Lucy, “and that the sugar, as it cools, may crystallise, just as we saw the crystallising of the alum for my basket.”

“True, my dear,” said her father. “The juice contains two sweet substances, sugar, which crystallises easily, and molasses, which does not crystallise. The boiling is also necessary to separate the sugar from the molasses and other substances contained in the juice. The great object is to obtain the sugar as pure as possible. Much is wasted by being over-heated, by which it loses the power of crystallising, and is converted into a substance resembling molasses.”

“ I have often burnt a piece of sugar in a candle,” said Harry : “ when burnt it remains sweet ; but it becomes brown, soft, and sticky.”

“ The same change takes place,” said his father, “ where a strong solution of sugar is heated in a vessel over the fire. When only a little hotter than boiling water, it begins to undergo this change, so that a part of it loses the property of crystallising on cooling, therefore great care is necessary in applying the right quantity of heat, neither too much nor too little. The manner of doing this in the West Indies is still very imperfect.”

Harry and Lucy were sorry to learn that so much of the sugar, raised by the hard toil of the poor negro, is spoiled : they hoped that the sugar boiled in England was not so wasted.

“ Much of the sugar refined in this country was formerly wasted in the same manner,” said their father ; “ but in conse-

quence of late improvements that is no longer the case?"

"What improvements?" cried Harry.

"They are what we are going to see this very morning," said his father. "The new process of refining sugar is what is used in the sugar house to which we are going. Do you know what substances are used in the refining of sugar?"

Harry said, that he had heard that bullock's blood was made use of; but in what manner, and for what purpose it was applied, he did not know.

"To clarify it," said his father. "When brown sugar has been dissolved in water, bullock's blood is mixed with it when cold; the blood coagulates on the application of moderate heat, and rises in the form of scum, which is then removed from the surface. But it has been found, that much sugar is lost by being mixed with the scum, from which it cannot afterwards be separated. This way of clarifying is not

used in the sugar house we are going to see.

"I am glad that we are not to see the bullock's blood," said Lucy, making a face expressive of disgust. "Do you remember, Harry, about *claying* sugar: the accident by which it was found out that clay was good for sugar—good for whitening sugar, I mean?"

"I do not recollect," said Harry.

"So much the better," said Lucy, "for I shall have the pleasure of telling it to you. It is a very curious thing about a hen."

"Tell it to us, my dear Lucy, I advise you," said her mother, "without raising our expectations, lest it should disappoint us afterwards."

"Then you must know, mamma, that one day a hen, after walking in some wet place, had clay sticking to the bottom of her feet, and she happened to tread on the top of a pot of sugar; and it was soon afterwards observed, that the sugar beneath

the marks of her footsteps was whiter than elsewhere. From observing this, and considering how it had happened, people thought of using clay to whiten sugar."

"Very ingenious," said Harry, "and Lucy remembered it well, just at the right time for us, did not she, mamma? I had quite forgotten it, but I recollect it all now. The sugar is put into a vessel of the shape of a sugar loaf, which is placed on its narrow end. Then clay, moistened with water, is put over the top of the sugar, and by degrees the water oozes very slowly down through the sugar, mixing in its way with the molasses, which it dilutes and carries along with it. I forgot to tell you that there is a hole at the bottom of the vessel. That hole is stopped at first by a plug, but afterwards a man takes out the plug, and lets the stuff run off that has oozed to the bottom."

"So men learned from the hen to clay sugar," said Lucy. "When next I see very

white sugar, I shall say to myself, Thank you for this, Mrs. Hen."

"You will be doing Mrs. Hen far more honour than she deserves," replied her father; "for in the sugar-house that we are going to visit, the operation of *claying* is laid aside. The art of refining, as now practised, is a new discovery; and it has arisen, not from mere lucky accident, but from judiciously combining sound scientific principles with accurate observation."

"How is that?" said Harry, drawing closer, and listening with great eagerness.

"You know already," said his father, "how brown sugar is extracted from raw cane juice, now we are to learn how it is made white, and hard, and crystalline, like that which you see every day. Brown sugar, as I have already told you, consists of two sweet substances, *sugar*, forming small crystals, and *molasses*. Molasses is combined with a dark colouring matter, which makes the sugar brown. To get rid

of this is the thing to be done. Now if a small quantity of water be added to a mixture of molasses and sugar, the whole of the molasses will be rendered fluid, but only a small portion of the sugar."

"Then," said Harry, "by putting this mixture into a mould, such as they use in claying, they would be able to free the sugar from the molasses."

"From a large portion of it," said his father. "Now perhaps, if I state to you a few facts, put them in proper order for you to consider, and then ask you a few questions, you may be able to invent for yourself the principle at least of the new improvements."

"Oh pray try whether Harry can, papa," said Lucy.

"There is nothing I like better than to learn in that way," said Harry.

"Pray help us when we cannot get on," said Lucy.

"Then to help you on one step," said their father, "I must tell you in the first place, that the *small* crystals alone of brown

sugar, are what are freed from molasses by this process. Before the *large* crystals can be purified they must be completely dissolved in water. When liquid, the colouring matter can be separated from the sugar. Now can either of you tell me how the separation is made?"

"I know that alum is used by the dyers to separate colours from liquids," said Lucy.

"Very true, Lucy," said her father.

"But I do not know why," said Lucy.

"Because alum contains an earth which has the property of attracting colours to itself. Also charcoal made of bones is sometimes employed for the same purpose. As soon as the colour is completely separated from the syrup, by these means, the liquor is put into a filter, and whatever runs through is pure sugar and water, from which the water must be evaporated. How?"

"I know, papa," said Lucy, "from what you before told us, that the syrup must not be heated in a vessel over the plain

fire; yet, in what manner to boil away the water, if not over a fire, I cannot imagine."

But after considering a little, she added, "Perhaps it might be boiled, as they sometimes do things in the kitchen, by steam, and then they are never burned."

"That is well thought of," said her father.

"But then there is such a quantity of this sugar," said Lucy, "it would require such monstrously large vessels, that I do not know how they could be well heated by steam."

"Some great buildings are heated by steam," said Harry; "so let the vessels required be ever so large, it might be done. It would be easy, would not it, papa, to conduct steam through pipes under the great pan that holds the sugar."

"You are both of you on the right road," said their father. "But something more must be thought of. By the method you have suggested we might heat the sugar,

but not boil it : a solution of sugar, if in an open vessel, requires a stronger heat to make it boil than water does."

" I should think," said Harry, " that by confining the steam, it could be made much hotter than boiling water, and then with the confined, compressed steam we might boil syrup, might not we ?"

" You might," said his father ; " and some persons do boil sugar in this way ; still there is some risk of over heating the sugar ; therefore think of some better way. Instead of raising the temperature of the steam, consider whether you know of any means of making fluids boil, without increasing the heat."

Harry considered for some time, and at length said, " I have seen water made to boil when only moderately warm, by putting it under the receiver of an air pump."

" How did that happen?" said his father.

" Because there was a vacuum," said Harry, " there was no pressure of the at-

mosphere. If we could place the sugar pan under the receiver of an air pump, that perhaps might do; but the quantity of sugar to be boiled puzzles me, father; the sugar vessels are very large, I believe. I could only boil a very small quantity in an air-pump; so that after all it would not do, I suppose."

"Why will not it do?" said his father. "Till you are sure that what you propose will not answer, never fly off to any thing else. Do not give up your ideas too hastily. You should not fix your imagination upon the particular receiver of the air-pump you have seen. To be sure you could not conjure a sugar-boiler into that small receiver."

"No, to be sure," said Harry, laughing: then becoming quite grave again, he went on thinking. "How shall I manage it? It is impossible to blow a glass large enough for the receiver."

"Why do you stick to the notion of a glass receiver, Harry?" said his father. "Do you think it essential to the having

a vacuum, that it should be produced in glass?"

"Certainly not," said Harry, "it is not necessary by any means. I only thought of the glass one, because that was the only receiver I had seen; but I perceive that any other substance that is air-tight will do as well as glass. How foolish I am! I remember now the pump, and the steam engine, where the vacuum is large enough; or a vessel might be made as large as could be required for the purpose."

"Now you have it, Harry. The sugar is boiled in a vacuum, and that vacuum is produced by means of an air-pump. The exact details I do not know, having never seen it done myself, but I hope we shall see it to-day, and so now let us set out."

THE sugar-house, which Harry and Lucy went to see, was a large building of eight stories high. The first circumstance which struck them on entering it was, that in several spacious rooms through which they passed, and in which the work seemed to

be going on, there were not many workmen. Lucy supposed that it was the hour of dinner, as had happened in some other manufactories which they had seen : but she was told that this was not the case; and that all the men, who were ever employed in this sugar-house, were now there. Few only were necessary, because so much was done by machinery. In truth, the men seemed of little importance. It appeared as if they were employed only as under-servants to the machines, and to do trifling things, which the mechanic and the chemist had not thought it worth their while to invent the means of effecting in any other way.

The large rooms and passages, through which they passed, were all warm, as Lucy observed, and yet she could not perceive a fire anywhere. She asked how they were warmed, and was told that she would soon see, as they were going to the place from whence the warmth came. Their guide, the gentleman who was so kind as to show them these works, took them to a

building, separate from the rest, in which there was a steam engine. The fire under its boilers was the only fire used in these works. All the rooms were sufficiently heated by the steam that passed through pipes to the different sugar vessels.

Harry was here perfectly satisfied, and he looked delighted and proud, when he heard how much was performed by one steam engine. It sent over this vast building, equable warmth, and supplied all the water that was wanted in every part of the works. It put in motion a mill for crushing the sugar, and other substances used in refining it; and it kept in unremitting action the pistons of a huge air-pump.

They followed their guide into a sort of out-house, in which the earth of alum was prepared, by adding quicklime to a solution of it.

They then entered that part of the building where the preparatory operations of cleansing the sugar were performed. They saw in the first place a

few workmen with naked arms, and in light clothing, suited to their hot work, stirring with huge shovels in a great pan, the raw brown sugar, such as it is when brought from the West Indies : they were stirring it up with a small quantity of water, not sufficient to dissolve it. It looked like treacle. This was afterwards poured into earthen moulds, of which there were great numbers in the shape of sugar loaves, such as those of which they had read a description, with a hole at the point, which was turned downwards ; and in these moulds it was to be left twenty-four hours to filter. In the course of that time the molasses would pass through into jars beneath the sugar-loaf moulds, and the sugar left behind would be in solid lumps, of a light brown colour. Some of the sugar thus purified was put into Lucy's hand ; she felt that it was soft enough to be readily crushed. It was now to be dissolved in water, which was heated by having steam passed through it. The

earth of alum, which they called *finings*, was then added to this solution, and thoroughly stirred about by passing currents of steam through it.

This was performed in a great square cistern, which had a double bottom and sides, with a space left between, sufficient to introduce the steam. The inner bottom and sides were perforated with minute holes; and through these holes the steam passed up into the liquid sugar. They heard a rapid succession of explosions, occasioned by the sudden condensation of the steam; and when the solution became hot, they saw immense volumes of steam rising through it. After this, the syrup was allowed to run into the filter. The filter appeared on the outside like a great square chest; and the inside was divided into parallel compartments, by coarse linen cloth, which was stretched over frames of copper. The liquor was admitted into every alternate cell, and was filtered by passing into the cells on either

side, which were empty. The syrup flowed out from the filter a transparent fluid, of a pale straw colour.

They were now conducted to the most remarkable part of the new apparatus, the evaporating pans, in which the water was drawn off from the syrup. These were made with double bottoms, so as to admit steam between the two for heating the syrup; and the pans were covered with domes of copper. These domes communicated with the air pump, the great pistons of which were kept at work by the steam engine. These served to pump out the air, so as to preserve, as far as possible, a vacuum over the liquid. The perfection of the vacuum was shewn by a barometer. The master of the sugar house informed them, that it required one hundred degrees less heat to boil sugar in vacuo than in the ordinary method, and that it was accomplished in less than one-fifth of the time formerly requisite.

After having been evaporated, the heat of the sugar was brought to a certain

temperature, at which it was found most disposed to crystallise. It was then poured into earthen moulds of the form of a sugar loaf, such as were before described, and in these it was allowed to consolidate. It is then of a tolerably white colour, and is purified for the last time by being washed with a solution of the finest white sugar, which is allowed to filter through it. The top and the bottom of the loaves, as being less pure, are then pared off in a turning-lathe, and the loaves are afterwards dried in a stove.

Lucy said, that before she came to the sugar house she had a general idea, from what she had read, and from what her father had told her, that sugar went through several processes of filtering, and boiling, and cooling, and crystallising, before it could be white ; but still she was surprised by seeing the number of the different operations, the size of the vessels, and the power and time necessary. She had not been tired by what she had seen, because she knew beforehand the general

purpose, and she had not been puzzled or anxious.

Harry was delighted at seeing that principle, which he had before so clearly understood, carried into practice with success, in such great works.

“I hope you will now acknowledge,” said he to Lucy, “that the air-pump is of some use in common life, and I hope you are convinced *now*, that the air-pump is almost as useful as the water-pump.”

Lucy acknowledged this; and said that Harry might well triumph for the air-pump.

“Think,” said Harry, “of its being applied to such different things as making sugar, and making ice; and not only employed for boiling quickly, but for freezing quickly. I do not think that Otto Guericke, or Mr. Boyle himself, could have foreseen all the uses that were to be made of their own inventions. I wish they could see all we have been shown this morning.”

"So do I," said Lucy; "I wish they could."

"All goes back to that one great principle of the vacuum," said Harry.

The gentleman who had shown them this establishment, and who had, with the greatest patience and politeness, explained every part of the business, was glad to perceive that he had given pleasure to the young people, and that they had attended to, and understood what they had seen and heard. He begged that they would rest themselves before they went away, and showed them into a room, where they found refreshments were prepared. He gave a cup of chocolate to Lucy, and another to Harry.

"You must," said he, "taste some of the sugar, which has been refined by the process you have just seen."

It was in a black Wedgwood-ware basin, which showed its whiteness.

"But, father," cried Harry, eagerly, "can you tell me who invented the method

of applying the air-pump so beautifully to this use?"

"I can tell you," said his father; "it was the invention of Edward Howard, brother to the Duke of Norfolk; he was an honour to his family; and I hope," addressing himself to the master of the sugar house, "that he has been amply rewarded for his ingenuity by the gentlemen of your profession."

"The fruits have been ample," said the master, "but he did not himself reap them; they are enjoyed by his family. He only just lived to perfect his invention."

The master of the sugar house then entered into a statement of the prodigious quantity of sugar saved by adopting the new process. Eight pounds of sugar, he said, were saved in each hundred weight; and he helped Harry to make a calculation of what that amounted to every year upon the total quantity of sugar refined in Great Britain.

Our party, having finished their choco-

late, thanked their host for his attention, and took their leave of him.

As you go down the hill from Clifton to Bristol, you may see in the city below a number of very high, black-looking buildings, in the shape of huge cones, from which still darker-coloured smoke, in thick black billows, is continually issuing. Some of these conical-shaped buildings are glass-houses. Lucy remembered her father's having showed her, and told her of what glass is made. She recollected the taste of the alkali, of the ashes of weeds, and the touch and sight of the sand. She recollected also the story of the accident, by which it is said the making of glass was first discovered; and, above all, she remembered the pleasure that Harry and she had had in seeing the *thermometer man* blowing tubes, and bulbs of glass, with his blowpipe. She wished very much to see some more glass-blowing. Her father took her and her brother one day to a glass-house. Her first feeling

on entering the glass-house was surprise at the great heat of the furnaces in which the glass was melted, and pity for the men who were obliged to work close to them. But when she observed how much they were at their ease, she by degrees was reassured, and able to be amused. She saw, in the first place, furnaces from which was taken the red-hot liquid glass. She was puzzled at first by the workmen calling this *metal*; but that was only their name for what was in reality, as Harry said, glass. She was much amused by seeing the operations of the glass-blower. First, the blowing of a glass bottle, and of a wine glass. One circumstance in the finishing of the wine glass struck her particularly. When he cut its rim round with a pair of shears, the glass, being as yet soft, yielded under the pressure of the shears, so that the wine glass was no longer quite circular, nor was the rim even. The workman then heated the wine glass again, and dextrously twirling

it round, it was brought back to the circular shape, and its rim was even.

Harry's father asked him why this happened.

He said he thought, that it was turned into a circular shape by the pressure of the air as it was whirled round while soft, as any other substance is made circular by the pressure of the tool when turning round in a lathe. And he thought that the air withinside of the glass prevented its being driven in, and squeezed together by the motion.

His father told him that he was partly right in his supposition ; but there was one reason, one cause, to which he had not adverted, and which he had not yet perceived. He would say no more, because, perhaps, by observing further, he would discover it for himself, in attending to another operation — the blowing of window glass, or *crown* glass, as it is called. First, a great pear-shaped bubble of glass, about a foot in diameter, was blown at the

end of an iron tube, to which, being soft and hot, it adhered. Then, by rolling the pear-shaped bulb upon a smooth marble table, and blowing into it, and by repeating these operations alternately several times, and by whirling it rapidly round near a hot fire, the bulb was brought from its pear shape into that of a globe. This globe at the part nearest to the furnace was the hottest and softest, and yielded most readily to the centrifugal force, as it was whirled round, and therefore it spread out most there, so as to become much thinner than at the part to which the iron tube was fixed. To make the glass of an equal thickness throughout was next to be done. The iron tube was broken off from the glass, leaving a hole in the globe, and then by means of a little hot glass, the tube was fastened to the opposite thinnest part of the globe, and whirled again. The thickest part being this time nearest the furnace, became hottest; and in its turn yielded the most, becoming thinner and thinner. As the globe was whirled, the

centrifugal force opened more and more the hole which had been left where the iron was broken off, till after some whirling the globe became a large circular plate of flat glass of nearly equal thickness.

Harry now perceived what he had omitted in the case of the drinking glass : the *centrifugal force*, or that force which arises from the tendency the parts of bodies have to fly from their centre, when turned round rapidly.

As he left the glass house, he continued his explanation.

“ I suppose, father, that the parts of the soft glass, as they are whirled round, tended to fly from the centre, and by so doing the globe became a larger globe, and the circular plates became larger circles, and all the parts flying off equally from the centre, the rim of the drinking glass became quite circular.”

“ It is,” said Lucy, “ not exactly, but something like a mop. Yes, Harry, a mop. When the maid twirls it round fast,

the threads of the mop all fly out as far as they can go from the centre; and if it is a wet mop, out fly circles beyond circles of drops."

"Well," said Harry, "you have made out your likeness to a mop better than I thought you could."

"I remember," continued Lucy, "the first day I ever heard of centrifugal force, or had any idea of what it meant; it was from you, Harry; when I was making a pancake, papa."

"A pancake, my dear! I do not remember your ever making a pancake."

"Perhaps it was a cheese," said Lucy. "Some people, I believe, call it a cheese. Not a cheese or a pancake to eat, papa; but I will show you as soon as we are in mamma's room."

Lucy kept her word, and whirling herself round the moment she was in her mother's room, the skirts of her petticoats flew out, and, as she popped downwards, while they swelled out, she exclaimed —

“ There is a pancake, papa, or a cheese, whichever you please ; and it is made, Harry, by centrifugal force, is not it ? ”

“ I have been very much amused,” continued Lucy, “ seeing the glass-blowing. Were not you, Harry ? ”

“ Very much, indeed ; and it has left a great deal to think of, and to inquire more about,” said Harry.

“ What more ? ” said Lucy.

“ A great deal,” repeated Harry. “ For one thing, annealing, I do not understand that.”

“ I recollect,” said Lucy, “ that when the man had twirled the wine glass round, and finished it, a boy came with a long pair of tongs, and seizing the glass ran away with it, as our man said, to the annealing furnace to be *annealed*. And when I asked what that was, and what was to be done more to it, the man showed me a pan in an oven, and I saw our wine glass, with many others, put into it to be heated again, and then to be left to cool slowly. The man told me they ought to take several

days to cool. This was done to make the glass less brittle, he said ; this is annealing. What more, Harry, would you know about it?"

"A great deal more, if I could," said Harry. "In the first place, I do not in the least know *why* annealing makes glass less brittle."

"Why? Oh! that is another affair. Why? Nor I," said Lucy.

"And I heard papa and the master-man in the glass house talking of a curious fact. He said, that 'when a glass vessel, of a particular shape, is allowed to cool immediately after being made, it will often sustain the shock of a pistol bullet, or any other blunt body falling into it from a considerable height; but a small splinter of flint, dropped gently into it, makes it fly to pieces with great violence.'"

"Indeed," said Lucy, "that is very curious."

"So papa said; and they went off to talk about Prince Rupert's drops. Oh, my dear, there are a great many, many

more curious things to be known about glass, and all the *whys*, more than in my life perhaps I shall ever know."

"But you need not know all the *whys*," said Lucy.

"But as many as I can," said Harry. "There was a man came in while we were in the glass house; did you see him, Lucy?"

"Yes. A gentleman, you mean?"

"I do not know whether he was a gentleman or not," said Harry; "he was a man."

"But I know he was a gentleman," said Lucy.

"By his coat? or his waistcoat? or his hat?" said Harry, smiling.

"By none of those," said Lucy; "by something better; by the way he spoke; by his tone, his language, I knew he was a gentleman."

"And I, by what he said, knew him to be a man of sense," said Harry. "He came to inquire for a person who grinds glasses for telescopes."

"Then he must be a man of sense, to be sure," said Lucy, smiling in her turn.

"My dear, you have not heard all. He was trying experiments to improve the making of those glasses. I did not understand all he said, but it made me very curious to know more."

"Papa seemed to like him," said Lucy.

"Yes," said Harry, "papa and he talked of what a fine useful discovery glass is, and how long before people thought of making all the uses that are now made of it."

It happened, that the next day Harry went with his father to the house of a physician, who had a good library, and while his father and the physician were busy, he asked leave to look for something he wanted in some of the books. The physician gave him leave, and to work he went, searching for a chemical dictionary or encyclopedia, in which he might find *annealing* and *glass*. The volume containing *annealing* was missing. He

thought this very provoking; but, like many things which we think very provoking, it was really fortunate, and well for him. Had he found it, he would not have understood the article; he had not the previous knowledge necessary, and he would have lost his labour, if not his patience. He went in search of *glass*, and there he found much that he could not, but some that he could comprehend. As he was both enthusiastic and indefatigable, he searched all through it, and had the great pleasure of picking out several entertaining things. Seizing on all that was suited to the present state of his knowledge, he left the rest for another time. One passage delighted him so much, from describing exactly what they had seen, and what he would have found it difficult to explain, that he scribbled a copy of it for Lucy. *Scribbled*, truth compels us to say, for it was scarcely legible. When he came to read it to Lucy he could hardly make it out, even with her best assistance, and she

could read his running hand better than he could himself. But, as she observed, this hand had run almost quite away.

“ My dear, I wrote it in a desperate hurry, and on a crumpled back of a letter, with a pencil that wanted cutting, and my father was standing up with his hat and his gloves in his hands. I thought he was going every instant, while I was writing the three last lines, scribble, scribble, scribble, as fast as ever my pencil could go.”

“ Thank you ! ” said Lucy, “ for doing it for me. But what is this about a *chain* ; I saw no *chain* at the glass house.”

“ Chain ! my dear Lucy ; it is *chair*,” said Harry.

“ Chair ! Oh, now I understand it all,” said Lucy. “ It is the description of what we saw—of the men making the drinking glass—the man sitting in the arm-chair, and blowing through his long iron tube ; then rolling it on the arm of the chair ; and the other man sticking on the foot of the glass, and then taking the chair. Oh,

I see it all again — it is very well described*.”

“ I am glad you think so,” said Harry. “ It is more than the man who wrote it expected.”

“ Expected ! did he ever think of me ?” said Lucy, opening her eyes very wide.

“ No, no, my dear,” said Harry, laughing. “ You may let your eye-brows down again. The author never thought of you in particular. I meant only his readers in general.”

“ Yes,” said Lucy, “ *my young readers* I suppose he said, as people often do in books ; is that what you mean, Harry ?”

“ I mean nothing,” replied Harry, “ but that the writer says he could hardly expect, by any description of his, to make glass blowing intelligible. Now that is all. Go on to something else.”

“ With all my heart,” cried Lucy, “ Here are some more scribbled notes of yours, Harry. What does this mean ?”

‘ Brave man, and quick ’ — ‘ Hands

* Edinburgh Encyclopedia.

through flames' — 'Covered with wet skins — 'Eyes of glass.'

"What can this mean?"

"Do you remember," said Harry, "seeing a great furnace at the glass-house? You saw only the outside. They could not uncover it to show the inside to any body, lest they should have let in the cold air. Into that furnace they put the earthen pots full of glass, which had been annealed, and they left them there to set, as they called it. If one of these pots happen to break it is a terrible difficulty to get it out and put another in its place. The getting out the broken one can be done well enough by a man at arms length from the fire, with a long iron hook, or a fork; but the man who is to put in the new pot can have no use of hook or fork; he must put the new pot into its place with his hands, passing them through the flames."

"Then indeed," said Lucy, "you might well call him *brave man*, and *quick*; he must do it as quick as lightning."

"But he could not do it as quick as

lightning, or do it at all," said Harry, "without precautions. He must be dressed, my dear, in skins, which are all as wet as possible; and they must cover him all over, all but his eyes, two holes are left for him to see through, but these are defended with thick glasses."

"I am sure I am very much obliged to you, Harry," said Lucy, "for bringing me home such entertaining things. That man, *brave* and *quick*, as you called him, was worth reading all *glass* through to get at. How many pages did you hunt through to find him?"

"I came upon him by accident," said Harry; "but I met with several other things which interested me, and I thought I would bring them away in my head for you; and I have them somewhere there, if I could but recollect them; but I cannot when I *try* in a hurry."

"Do not *try* then," said Lucy. "When I try too hard to remember, I never can recollect what I want, but then it comes all back again when I am thinking of

something else. So now, Harry, look at this nice little glass tumbler, which papa bought for mamma's dressing box, in place of that which I broke. It is prettier than the old one; look at its pretty white leafy border. That is *ground* glass, papa said; and this part below, like crystals, is cut glass; and papa told me how this was done."

"Two of the very things I was trying to recollect," said Harry. "Then I need not tell you about that."

"No," said Lucy. "What a beautiful, transparent, clear, clean thing glass is," continued she; "and how very useful, and in how many different ways. Drinking-glasses and looking-glasses—you may smile, Harry; but men use looking-glasses, as well as women."

"Yes," said Harry, "and for better purpose too, than looking at themselves. They use looking-glasses, you know, for some astronomical instruments."

"Yes, and for shaving too," said Lucy, "or they would cut their throats. Mighty

grand you were about the astronomical instruments!" added she, laughing. "But let me go on my own way in honour of glass, to tell you all that I know. Besides looking-glasses, there are magnifying and diminishing glasses, both very useful and entertaining; and then spectacles! Oh, Harry! what would grandmamma do without them? and how happy she is with them! reading and working as well as I can at eighty-six. What a wonderful invention spectacles are, by which people can see so many years longer than they could in former times! Spectacles, I think, Harry, are the most ingenious things people ever made of glass."

"Do not forget telescopes, my dear," said Harry: "the most wonderful of man's inventions."

"How curious it is," said Lucy, "that all these things, spectacles and telescopes, would never have been thought of but for that first bit of glass, which the shipwrecked sailors observed, when they were boiling their kettle on the sand, with the

the fire made of sea weed. Do you remember, Harry, my father's telling us that story?"

"I do," said Harry; "and now that puts me in mind of what I wanted to say to you. It was about that story. It is told in the book I was reading to-day, and I was glad to meet with it. There was a little difference; the sailors supported their kettles on the sand with pieces of fossil alkali, nitre, with which their ship had been loaded."

"And in our old story," said Lucy, "the fire was made of weeds, and the alkali came from their ashes, which burned with the sand, and made glass. There is very little difference in the stories. It all comes to the same thing."

"I know it does," said Harry. "But I was going to say something quite different."

"Say it then, my dear," said Lucy.

"What time did you think that story happened?" said Harry.

"I do not know," said Lucy. "I hardly

ever think about *time* in stories. I think it was in former times—a great while ago.”

“In the time of Pliny, or before?” said Harry; “he tells the story.”

“Very likely,” said Lucy. “I do not care who tells it.”

“But, my dear,” said Harry, “what I want you to care for is the wonder that it should be so long since glass, and the way of making it, were first discovered by that lucky accident, and yet that it should be hundreds of years before it was brought into common use. You know the ancients, the Greeks and Romans, had not glass as we have.”

“I thought that they had glass bottles in old Roman times,” said Lucy. “I remember something about a bottle of glass in the Roman history, which a man brought to the Emperor Tiberius (I think), and he dashed it to pieces when he was provoked, and the emperor put him to death for it. Do not you remember, Harry, my reading it loud to mamma, and your being so angry with that tyrant?”

"I remember that perfectly well," said Harry; "but that was only one particular bottle."

"But besides that particular bottle," said Lucy, "I recollect hearing Mr. Frankland tell mamma, that there were plates of glass found in the ruins of Herculaneum."

"Did he?" said Harry.

"Yes," said Lucy, "and from that it is supposed, that glass windows were used by the ancients."

"Perhaps so," said Harry. "But, my dear Lucy, to go no farther than England, my book says, that the English had not glass windows for many hundred years after that. The windows of houses and churches were covered with linen cloth, till towards the end of the tenth century."

"You mean till about the year 999!" said Lucy.

"It was not till after the days of Queen Elizabeth," said Harry, "that it was quite common for houses to have glass windows."

"How very stupid people must have been in those former days then," said Lucy.

"So it seems," said Harry; "and yet I suppose they were not naturally more stupid than we are now. Recollect Virgil and Homer, my dear. But then the ancients had not many men of science."

"And then came the dark ages, as our history calls them," said Lucy; "and in the dark ages I suppose people fell asleep, and could not think of glass, or any thing else. Even when they awakened there were not many that could write or read, you know, Harry."

"They had very few books to read," said Harry, "except the ancient Greek and Roman books over again, and they had scarcely any books of experiments I believe."

"They had only manuscripts," said Lucy, "written on parchment, or on *papyrus*. I remember papa once showed me a *papyrus* manuscript in a museum, and I saw parchment rolls too, which the ancients called books."

"And what work there must have been making copies enough of these manuscript

books," said Harry, "for people to read. And how few copies of books a man could make after all: and he could do nothing else."

"No wonder the people were stupefied," said Lucy.

"But then happily was invented the grand art of printing," said Harry.

"Yes, I remember," said Lucy, "seeing it in capital letters in the Memorable Events. And when I first read of it I did not know why so much was said about its being such a grand invention. Now I begin to understand better. By the bye, Harry, you have seen a printing-press. I never saw one, and I should like to see how they print. I think that my father was asking something about printing-presses in Bristol."

"Yes," said Harry, "he told me that he will take you to see one if he has time."

"I wish it may be to-morrow," said Lucy. "We have very few days more to stay at Clifton: I hope papa will have time to show me the printing-press. But

in the mean time, Harry, will you play at cup and ball with me.: look what a pretty ivory cup and ball mamma has given me. I thought of it several times while you were talking of glass, but I would not interrupt you. Now let us have a trial on the spike. Which will catch it the oftenest? Will you spin the ball for me?"

"What is the use of spinning it?"

A question easily asked—very difficult to answer.

"MAMMA, I am sorry that you could not go with us to see the printing-press to day, for it was very entertaining. And look," said Lucy, "I am not covered with printer's ink, as you said I should be."

"If you did not take care, my dear, I said. Did not I?"

"Yes, mamma; but I did take care you see, for I have not a single spot, and yet I saw every thing perfectly. Mamma, you have seen printing so often, I suppose, that it would be tiresome to describe it to you.:

And I shall only tell you, that it was done almost exactly as is explained in our *Book of Trades*, in the chapter of *The Printer*. Do you remember my reading it to you, mamma? and the picture of the letter-press printer? And at the end it was said, that after reading this, young people should endeavour to go through a printing office. I asked you directly, mamma, to take me to see one, and you said that you could not then, but that you would some time or other; and now the some-time-or-other, which I thought never would arrive, has come to day. I saw the letters, or the types, all in their square divisions in their cases, which lay sloping within reach of the compositor, who with his *composing stick* in his hand, picked out the letters, and placed them in the *form*. Then another man inked their faces, with a black puff-ball, and afterwards the wet paper was pressed down on them. I knew and understood almost every thing he was going to do, mamma, from recollecting the description. This was very pleasant. There

was one thing though, which I had mistaken ; when I took up one of the types, I saw that the letter stands out from the face of the metal, it projects : now I had always fancied, that the letters were hollowed out, cut into the types, as the letters for instance of your name, mamma, are cut into this seal."

"How could you think so, Lucy?" said Harry; "you know that would be engraving, that is the way engravings are made."

"Yes, now I recollect, I know that is the way engraving is done, but I thought in printing books it was the same; and I know now what led me into the mistake, it was our little ivory letters, which we put together so as to spell out words, they are all cut *into* the ivory, and filled up with ink."

"But does not your Book of Trades, Lucy, describe how the letters are made," said her mother.

"No, mamma, not that I recollect," said Lucy. "I dare say the author sup-

posed every body must know it, but I did not."

"That is my fault, I am afraid," said her mother.

"Not yours, mamma, but the fault of the man, the author of the Book of Trades, if it is any body's fault. But, indeed, it must be very difficult for great grown-up old authors, to recollect the time when they did not know every thing or any thing themselves, and very tiresome to them to explain every little particular from the very beginning. It must be difficult too for wise authors to guess or conceive the odd sort of little foolish mistakes that children make."

Harry waited till Lucy had done speaking, and then told her, that the manner in which letters are made is described in the Book of Trades, under the head *Type-founder*.

"Is it indeed?" said Lucy; "then I read very carelessly. But I remember the calico printer perfectly well, and how his types, or his blocks and patterns are made,"

I know the pattern is first drawn on the block of wood, a leaf and flower for instance, such as there is on this curtain: then with a very sharp knife, or a little chisel, they cut away the wood all round the pattern, and between every part of it, so as to leave *it standing up and standing out.*"

"In *relief*," said her mother.

"Then they rub colours on this pattern," said Lucy.

"As the other printer rubs ink on his types," said Harry.

"And the calico printer stamps it down on the calico."

"Just as the letter-press printer did the paper on the types," said Harry.

"How comes it, Lucy," said her mother, "that you remember so accurately all this calico printer's business."

"Oh, mamma! for an excellent reason, which Harry knows. Do not you, Harry?"

"I do," said Harry, smiling.

"Mamma, Harry was a calico printer once, and printed a blue starred gown for my doll," said Lucy.

"And a pretty blotted, blurred gown it was," said Harry.

"I liked it the best of all her gowns, and so did she," said Lucy. "And we were so happy doing it, mamma, except when Harry cut his finger hacking at the block," added Lucy, shrinking at the recollection.

"What signified a cut," said Harry; "but I broke the point of my knife, and that was the reason the star was but a botch at last."

"The worst of it was," said Lucy, "that the stars all came out the first time it was washed. But that was not your fault, Harry, but the washerwoman's."

"More probably the fault of the colours you used," said her mother; "or else, why did not the colours wash out of your own gowns? the same person washed them."

"That is an unanswerable argument," said Harry.

"Therefore I will not attempt to answer it," said Lucy.

"I am glad of it," said Harry; "I want

to go on to something else. Mother, it is very extraordinary that printing should not have been invented for so many hundreds of years."

"The same thing we said about glass," cried Lucy.

"It is surprising that the ancients should not have invented printing, Harry," said his mother, "because they had, in common use, contrivances which might, with a little more thought and ingenuity, have led them to the invention."

"What do you mean, mamma?" said Lucy.

"I think my mother means their seals and their medals," said Harry. "Their seals were made like ours, with letters cut in."

"Yes, in *intaglio*," said his mother. "But how did you know that, Harry!"

"I knew it, mother, from one of the large books of prints, which you used to lend me to look at at night, when I was at home."

"Montfaucon?"

"Yes, mamma, there were in that book figures and descriptions of several very large Roman seals, in which there were names in capital letters. I brought you the book one night, mamma, when it was so large and heavy, I could hardly hold it I remember; and asked you to tell me something of these seals, and to read and translate a bit of the description to me, for it was French. And you were so good as to do it, mamma."

"I am very glad I was, since you remember it, and that it is useful to you so long afterwards, my dear boy," said his mother.

"It said, that those great seals were used for marking some large earthen vessels, in which the Romans kept their wine. They stamped them down on the clay vessels, while the clay was soft, and then it hardened and the letters remained."

"Just like our seals on wax," said Lucy.

"I think, mother," continued Harry, "that all those great seals had the letters cut in, and not in relief."

“Yes, and of all which he gives representations. I think he never found any with the letters in relief; but we are sure that there were such in use among the ancients, for I recollect it is said, that some of the names on those wine vessels were *cut in* to the clay, that is in *intaglio*; which you know is a proof that they were made by a seal or type that was in relief. In the ruins of Pompeii, loaves of bread have been found with letters stamped upon them, and Virgil mentions the branding of cattle.”

“Then,” said Lucy, “they actually did know how to print, without knowing it. I wonder when they had such trouble in copying writing, that they never invented a printing press: how stupid! when they saw the letters on the jars standing before their eyes,” continued Lucy; “but I suppose, that from only seeing one name or a few letters at a time, it never came into their heads.”

“Were there any Roman seals ever found, do you know, mother,” said Harry, “of the rare kind, with the letters in relief,

in which there was more than one word?"

"Yes, I believe," said his mother, "that the Duke of Richmond has in his collection a seal, on which there are four words, the four names of the Roman to whom it belonged; and this seal belonged, it is thought, not to any emperor, or great man, but to some private individual; therefore it is believed that such seals were in common use among the Romans."

"And they never invented printing after all," said Lucy; "the Germans or the Dutch, I believe, invented it."

"And how did they come to it at last, do you know, mother?" said Harry.

"That is disputed, and not yet settled, my dear," said his mother. "Some say the hint was taken from these Roman seals; others, from the seeing the names of saints cut on blocks of wood, under their images. Other people think that the idea was suggested by the seeing the manner in which cards were stamped."

"Indeed!" said Lucy. "But those

were from wooden blocks, not metal letters, or types."

"True, and the first books were printed from wooden blocks," said her mother. "Some of these are still preserved in public libraries, as curiosities."

"I should like to see one," said Lucy.

"You would see how coarse they were, and how inferior to our improved printing."

"To be sure, from these clumsy wooden blocks," said Harry; "but I suppose they soon got rid of those."

"The Chinese use wooden blocks still, I believe," said his mother; "and it is said, they had the art of printing long before it was known in Europe."

"More shame then for them," said Lucy, "since they have not improved it all this time. What! use wooden blocks still. What blockheads."

"Gently, gently," said her mother. "There may be some reasons for this, which you do not know: they have not our alphabet."

"But without going off to defend or attack the Chinese, let us go on with our own affairs," said Harry. "What came next, mamma; and how did the people get to the printing press?"

"The first improvement made after the printing whole words with wooden blocks, was the making moveable letters; then the same letters could be used over and over again, and as many made as they pleased. These were first of wood, afterwards they tried metal; and when they had moveable types of metal, they next found the readiest way of fixing these in frames, and of inking and stamping a heavy weight down upon the paper, which was laid over them. There was the printing press."

"What was the name of the man who first made a printing press?" said Lucy.

"That is disputed too," said her mother. "Some say a man of the name of Scheffer, a servant of a Dr. Faustus, and some say Faustus. Poor Dr. Faustus should be allowed the glory of the invention, as it brought him into some difficulties."

“Difficulties! how, mamma, such a great convenience as the art of printing?” said Lucy.

“When he carried a parcel of his printed Bibles from Germany to Paris, and offered them for sale, as manuscripts had formerly been sold, the French, considering the number of copies he had made, and finding them all to a letter the same, which was a degree of exactness beyond what any the best copyist could have accomplished, suspected that he was a wicked magician, and, by threatening to pursue him as such, and to burn him, they extorted his secret from him.”

“How cruel!” cried Lucy.

“How unjust!” exclaimed Harry. “I would never have told it to them.”

“I would rather have told it than have been burnt alive,” said Lucy.

“It is very happy for us that we do not live in those days of ignorance,” said their mother. “Men are honoured for inventions now, not persecuted or burned.”

“That is a blessing,” said Harry. “But,

mother, how much you know about printing and printers, and printing presses, and all the history of the invention: how could you remember it all, and have it ready for us the very moment we wanted?"

"Very easily, my dear," said his mother, smiling. "Shall I tell you how and why? When you went with your father this morning to see the printing press, as I could not go with you, lying on my sofa here, I read an account of printing; for I was determined to be as wise as you, by the time you came back."

"And a great deal wiser, mamma," said Lucy.

"A great deal, because you picked out all the things I did not know, and wanted to know," said Harry. "Thank you, mother."

His mother asked Harry if he had found out whether there was in Bristol any printing press moved by a steam engine: Harry answered, that he did not know.

"You do not know! but did not you

put your father in mind to inquire?" said his mother.

"No, I did not," said Harry.

"That is very odd," said Lucy, "you who never forget any thing of that sort."

"It was unlike you, indeed, Harry," said his mother, "you were so intent upon it yesterday. I recollect your surprise and admiration when your father told you of the double printing press, moved by a steam engine, which he had seen in London, where, without hands, the types are pressed against the paper, and the ink spread just in the quantity required over the letters; and which can in one hour print 900 sheets on both sides. My dear Harry, is it possible you can have forgotten this?"

"No, mother; I never said I had forgotten it," answered Harry.

"Then why did not you put your father in mind to inquire whether there was any such printing press in Bristol? When you left me, your head seemed quite full of it."

"Yes, mother — but —"

"But what? pray tell me, for I cannot understand your silence, my dear," said his mother.

"Only I thought, mother, that Lucy would like better to see the plain common printing press first; because she said that she should like so very much to see exactly what is described in the Book of Trades. Therefore I did not ask papa about the steam double printing press, because I thought that would puzzle and hurry her, and that she would not see the thing just as she wished; and you know I can see what I want another time perhaps."

"How very kind, Harry," said Lucy. "So that was your reason, and you did not forget? But you never told me that you gave it all up for me. If mamma had not by accident asked, I should never have known. Oh! Harry, why did not you tell me?"

"What signifies telling, or talking about it," said Harry. "It was nothing, but just what you would do for me. I do not

forget the fairy you gave up for me, Lucy, the other day, the new Corsican fairy!"

"A steam-boat will set off from Bristol to-morrow morning! Oh, father," cried Harry, "can you take me to see it?"

"I can, Harry, and will with pleasure," said his father.

"And Lucy?" said Harry, in a tone which showed, that his joy, great as it was, could not be complete without her.

"And Lucy," said her father, "if the day be fine; but I cannot take her if it should rain."

Next morning, Harry was up by day-break, peeping out to see what kind of a day it was likely to be. A cloudy morning it was, at five o'clock; threatening rain desperately between six and seven; raining downright between eight and nine; and presently, it not only rained, but it poured so that all hope was over for Lucy. Splish! splash! Harry trudged after his father, through the dirty streets,

scarcely hearing, not at all heeding, the rattling of carriages, rumbling of carts, rolling of barrels, jarring and jangling of iron bars dragged upon *drays* without wheels, over rough pavements, with all the indescribable clatter, and clangor, and clamor, and stunning din, of this most noisy of noisy cities. Nor did he feel the rain which poured over him. But when the heavy shower ceased, and when dripping umbrellas closed, and the sun, through the clouds, gave promise of a better day, Harry entreated his father to let him run back for Lucy. If his father would but wait for him five minutes, in a shop — “this bookseller’s shop, papa, I will be back in less than five minutes, and I will bring her very quickly and as safe as possible through the streets; may I, papa?”

“No,” his father said, he could not wait, for the vessel would set off punctually at the appointed hour, and if they delayed five minutes, they should be too late. Then Harry thought they could never walk fast enough. On he kept, before

his father, the rest of the way, till they came to a great crowd of people. Not only the lower class of idlers, but persons of all ranks assembled to see the departure of the steam-boat. Harry darted quickly after his father, while heads and elbows closed over him. He could not see farther than the backs and legs of the people before him, for some time ; but he pierced through the darkness of the dense crowd of tall bodies, and emerged, at last, from under the elbow of a six-foot-high sea-captain, into full daylight. He found himself standing on the stone-pier of a large dock, at the very edge of the water, in the front row of a multitude of spectators, who covered the quay. Through the buzz of voices, the first thing he distinctly heard was—

“ *She* will not get out this quarter of an hour—*She* will not get out till the tide lets them open the dock-gates.”

She, as Harry knew, meant the steam vessel ; he rejoiced to find that they were in such good time. Now he had

leisure to breathe, and to look about him. Close beneath the stone pier, on which he was standing, were several vessels, among which he first distinguished the steam-boat, by the faint grey smoke, which he saw rising from a black iron chimney, that stood in the middle of its deck. The boat had sails, but they were not spread, they were close furled, as unnecessary for the voyage. It appeared as if there were fewer sailors on board than in the other vessels: but all was in motion on her deck, and on the adjoining pier. Two men were rolling a chariot over planks laid from the pier to the edge of the vessel; others were dragging to its right place on the deck, another carriage; others held horses on the quay, who were to go into the boat, and who, with ears pointed forward, and expanded nostrils, drew back, and yet in a few instants patiently submitted to their fate: while the gentlemen to whom they belonged, or their servants, anxiously called out, giving directions about their valuable and their favourite

horses. Groups of people, with bundles, baskets, boxes, bags, and umbrellas in their hands, stood by waiting, impatiently, till the horses and carriages were disposed of, and then they stretched their necks and their hands, and gave in their goods, with eager directions, to a sailor, who, balanced on a board, scarcely appearing even to listen to them, handed the packages as fast as he received them to another sailor behind him, repeating continually to the anxious proprietors—

“ They will all be safe; all will be taken good care of, *Sir*,” or “ *Madam*,” as the case might be.

Harry was astonished by the vast weight, number, and bulk of things, animate and inanimate, which were stowed on board, loads of boxes, and parcels, and baskets, trunks, chests, or packing-cases, besides the carriages and horses, and, after all, passengers crowding in innumerable. All these to be carried by steam, full against the wind, which was now rising. There was a man in a blue jacket, with a large

straw hat on, standing near Harry. He was a sailor, belonging to one of the sailing-packets which lay in the dock, and which was not likely to sail this day, wind not permitting. He eyed, with no friendly eye, these preparations going forward with such alacrity. His brow darkened, and with a sulky look, he began to whistle. One belonging to the steam-boat, who heard him, smiled and said —

“No need to whistle for a fair wind. *We can go without a wind, or against it.*”

Provoked beyond endurance by this boast, the old sailor swore — yes, I am sorry to say he did swear — that for his part he would not go on-board a steam-boat for both the Indies, and a puncheon of rum into the bargain, not he! He would rather, in the roughest gale, be out at sea, in an honest sailing packet, with a gale in his teeth, than go on board such a thing as this, the finest day of the year.

This speech making little impression upon the by-standers, he added, that “It

was well for *her* it was fair weather, for she would never stand a gale."

Then shutting one eye, and looking upwards with the other, he observed, that if he was not more mistaken than ever he was in his days, the wind that was rising would soon blow a storm, which would bring, as he prophesied, evil to all who were going on board her.

Among the intended passengers who were standing by, was a poor decent looking woman, in a black bonnet and cloak, with many bundles in one hand, and holding by the other a sickly looking little girl. The woman listened with great anxiety, and the child looked exceedingly frightened, whilst this sailor was speaking, and grew paler and paler, when he went on telling of the dangerous accidents he had heard of happening on board steam-boats — boilers that had burst, and scalded some to death, or blown all on board and the vessel to pieces. The child, on hearing this, let go a cocoa-nut, which she had been hugging

close to her bosom, and clung with both her hands to her mother. The cocoa-nut would have rolled into the water, if Harry had not stopped it; but he picked it up, and returned it to the little girl, offering to put it into a bag which her mother tried to open, but her hands trembled so much, that she could not untie the strings; Harry disentangled them for her, and begged her not to be alarmed. The sailor persisted in saying, that she had good reason to be afraid, adding, that as her child was so much frightened, and as her own heart failed her, she would do much better not to go in the steam-boat, but to wait till the next day, and take her place and a comfortable birth in the sailing-packet, which would be off early in the morning.

The poor woman said that she could not wait for the morrow; and though she still trembled, she tried to speak steadily, saying that her heart did not fail her; that she was determined to go now, and in the steam-packet, for it was the cheapest and the quickest way she could go to her

mother, who was lying dangerously ill, in Dublin, and if she missed this day, she might never see her mother alive.

The tears rolled down her cheeks as she spoke: the sailor still urged her not to go, and risk drowning her child. Harry called to his father, who was talking to some gentlemen, and had not heard what passed. Harry begged his father would come and tell this poor woman whether he thought she might safely go in the steam-boat or not. Not only his father, but the gentlemen who had been talking to him, came immediately, and assured the poor woman, that, in their opinion, she might go with perfect safety. One of these gentlemen was an American; he told her that he had, in his own country, been hundreds of times, and many thousand miles in steam-boats, and had never seen any accident happen.

Harry's father added, further to encourage the poor woman, that the two gentlemen, who were speaking to her, had themselves taken their passage on board this

very packet. She thanked them, and wiping away her tears, said, she had been determined to go at all hazards ; but now she had no fears. The sailor sulkily turned away and walked off.

A call now came for all to go on board, as the tide served, and they were just opening the dock gates. All hastened on board, except the poor woman ; but the moment she began to move, her child screamed, and clinging round her legs, cried, " I know it will burst ! I know it will burst ! It will scald me to death ! It will kill us ! Oh, mother ! mother, do not go ! Oh, mother ! mother ! " The poor woman did all she could to soothe her, but in vain ; the child was so terrified that it listened to nothing ; and when its hands were loosened from round its mother's knees, and when she tried to lift it up, the little girl caught fast hold of Harry's arm, struggling with all her might ; a messenger came, saying that the captain would not wait : the woman again trembled excessively, and grew pale.

"Perhaps, father," said Harry, "if I offer to go on board, the little girl will come with me, when she sees that I am not afraid."

"Try," said his father.

Harry spoke very gently to the child, who stopped crying, and listened to him, and let him lead her on, when she saw that he was not afraid. He thus got her into the boat to the woman's satisfaction. The child still held fast hold of his hand, saying, "Do not leave me, do not go."

"I must go," said Harry, "and I am very sorry for it, for I should like to stay very much."

His father, who had followed him, and who had learnt that they could go a few miles down the river, and be put on shore at a landing place, told Harry, that, since he wished so much to go, he might, and that he would accompany him. Harry thanked him, and was delighted. The gates were now opened, and they were slowly towed out of the dock, and between the narrow piers, while the swing bridges,

turned back, were covered with spectators. A band of music stationed on the deck played. The sun shone bright, and all looked happy. Yet Harry was a little disappointed by their being towed. He told his father, that he had thought it was all to be done by steam.

“Wait a few minutes, and you will see that it will be so,” said the captain, smiling.

As soon as the vessel had reached the river, and passed the place where a ferry boat was crossing, the smoke from the chimney issued thicker and thicker, and spread like a gigantic pennon over their heads. The towing had ceased, the paddle wheels were set in motion, “And now, my boy,” said the captain, “we are going by steam.” And easily and swiftly they went, gliding rapidly on between high hills and rocks on both sides of them. The lofty crescents, terraces, and hanging gardens of Clifton, seemed to fly back as they passed. In a few seconds, the ferry boat lessened and vanished. They passed the majestic rock of St. Vincent, crowned

with specks of human figures. Birds hovered round their nests in the rock. As they passed on, the captain pointed to Leigh Woods and Nightingale Valley; but scarcely had he named them, when new scenes were before them. Harry felt afraid that they were going too swiftly, and that his pleasure would too soon be at an end. He had never stirred from the spot where he stood, when he had first entered the boat: the child, having fast hold of his fore finger, had by this time, lulled by the music, and the easy motion, fallen fast asleep with her head in her mother's lap. Harry longed to go to his father, who was walking up and down the deck, with the captain and the American gentleman, talking as he heard, every now and then, as they passed him, of something entertaining about steam boats. But he thought he could not draw his finger away from the child without wakening it, and the mother looked up piteously in his face once, when he offered to move, saying —



"This is the first sleep she has had these three nights. She has been very ill."

"Try if you can put in your finger instead of mine," whispered Harry, and gently unclosing the hand of the sleeping child, he drew out his, and the mother slipped in hers. The hand closed again, the child did not waken, the mother smiled, and Harry, set free, ran off joyfully to his father. He found the gentlemen were eagerly claiming for their several nations the honour of bringing into general use the invention of the steam vessel.

The captain, who was a Scotchman, claimed it for the men of Glasgow. The American maintained, that the number of steam boats in America, and the years they had been there in use, proved that they had first felt the value of the invention. This could not be denied, the Scotchman admitted; but it must never be forgotten, that the first was sent out to America from Glasgow, and that a Scotchman went out with it, and that the engine was one of Boulton

and Watt's; without this it could never have been set a-going.

An Irish gentleman here begged leave to remark, that the experiment of the last winter's trial of them between Dublin and Holyhead had been *undeniably* the most fair and satisfactory ever made, and had established steam vessels in the three kingdoms. An Englishman who was present, and who was silent till the last, said only that he was content, since none could doubt the original invention was English, and the whole establishment of this glorious and useful discovery in *Europe* was exclusively British. Harry's father, to whom he appealed, had the candour to mention a French gentleman*, who many years ago tried an experiment with a steam boat on the Rhone at Lyons. By listening to all that was said, Harry learned in short the history of this invention. It was first thought of nearly a hundred years ago, by a Mr. Hull, for towing vessels in and out

* The Marquis de Jouffroy.

of harbours; but he only made the proposal, not the attempt, and he had no idea of using it in any other manner. The first person who actually placed a steam engine in a boat, and tried the experiment, was a Mr. Patrick Millar, at Glasgow; the remains of the boat are yet in being, and the Scotch gentleman said he had lately seen them. Several persons in Scotland and England about this time proposed to employ steam vessels; but they did not come into general use, till a model of one was carried from Glasgow to America. Its successful establishment in that country, on the prodigiously extensive lakes and rivers of the new world, proved its practicability, and brought it at last into use in Scotland, England, and Ireland.

Harry was surprised to hear that a hundred years should have passed between the first invention and its being brought into general use, and asked why it had not succeeded at first as well as at last. Several reasons were given: the Scotch captain said, that vessels were not originally made

strong enough; that the improvements lately adopted in ship building had rendered it possible to employ a greater power of steam than they could formerly, without danger of destroying the vessel. The Englishman observed, that people had been for many years too much occupied in applying the steam engine to other purposes in England, to think of adapting it to boats. And indeed it was scarcely necessary till now, that commerce has increased so rapidly, and the goods and people to be carried on canals, rivers, and sea, are so numerous.

Harry was much obliged to the gentlemen who took the trouble to give these explanations in reply to the question he had asked, and felt a little proud of being treated so much like a reasonable person. He took care not to interrupt them with more questions, though there were many he wished to ask. But, at the first pause, he whispered to his father, and asked whether it was possible for him to see the machinery of this steam vessel. He could

not see the paddle-wheels, of which he had heard the captain speaking. He wished very much to understand how these were moved by the steam engine, and how they worked the ship forward so rapidly and powerfully against the wind, which now blew strong. His father told him, that he could not show him the machinery, while they were going on, but he would ask the captain to show it to him, whenever they stopped, which they were soon to do at a place called Lamplighter's Hall. This was now in sight, and in a few minutes they reached it, and Harry heard an increased sound of the rushing of the steam, which was let out before the vessel could be stopped. The noise of the working of the machinery ceased, the vessel stood still, and a rope was made fast to the shore. Some of the passengers were to be set down here, and others taken up; and during the delay this occasioned, the captain had time to attend to Harry's request. He was a good-natured man, and took pleasure in gratifying, as he said, the boy's laudable curiosity.

He showed him how the engine is connected with the paddle-wheels. They looked something like the water-wheels of a mill, and as they turned, and as each vane struck upon the water, he perceived that it urged on the boat, like the oars of the boatmen, whom he had seen rowing. He asked at what rate they had been moving to-day, and was told, "about eight miles and a half an hour." They had been going against the wind, but with the stream. He asked what is the fastest rate at which steam vessels can go, and was told, by the American gentleman, eleven miles an hour; but in England, as the English gentleman said, ten miles an hour. The Irish gentleman asserted, that during the last two years the passage from Dublin to Holyhead had always been performed at an *average* rate of about seven miles an hour, and that the mail, which was carried by the steam packets, had scarcely missed a day even in the most stormy weather. He asked Harry if he had suffered from sea sickness. Harry had

never been in a ship, and had never been sick in a boat. The river had been so calm to day, that they had scarcely felt the motion of the vessel.

“Well, some time or other, you will feel what it is, and then you will be thankful to the steam packet, which at least lessens the time of the suffering, and affords the certainty that it will be over in a given number of hours.”

Harry listened to his father and these gentlemen, who spoke of the great advantages to commerce and to society from this quick communication between distant countries. Enlarged views opened upon his young intelligent mind, and he exclaimed,

“What a grand invention! I am glad it was made by —”

Englishmen, he was going to say, *Britons* he did say, which word satisfying the Scotch, the Irish, and the Englishman, they all smiled upon him.

“Pray, young gentleman, what do you think of us Americans,” said the American.

"We have done more than any of you, I guess. Recollect that we have at the least three hundred steam boats in constant use."

"Three hundred!" said Harry, with a tone of admiration. "But recollect," added he, "that it is by our help that you have all these. You know we sent the first model to America."

"We Scotch," interposed the Scotchman, in a low voice.

"That model helped, I acknowledge," said the American.

"Then," added Harry, "if we helped you in the beginning, you that have a whole new world to yourselves, will help us in the end, I hope."

"All fair, and I hope we shall; so shake hands," said the American, shaking Harry heartily by the hand. "For one, I promise you, if ever you come to America, my little man, I will make you heartily welcome; and if you please, you shall go in a steam boat on the Mississippi, and

Missouri, and on the Ohio, some thousands of miles. That would please you, I *guess*?"

"I am sure it would," said Harry. Gratitude to these kind gentlemen, and the enthusiasm which had been excited in Harry's mind, quite overcoming his habitual taciturnity, he went on talking of this glorious invention. "After a hundred years working at it, it is at last," said he, "brought to perfection."

"Perfection!" repeated his father. "Harry, that is saying too much."

"Too much for any human invention, sir," said the Scotchman. "And as we know even at present, there is much more to be done for these steam vessels."

"And much is doing," continued Harry's father; "men of science and genius are going on continually, making improvements."

"Just before I left London," said the Englishman, "I heard of a number of capital improvements, preparing for our steam

boats, which will make them more durable and safer than they are at present."

The American nodded with an air of great satisfaction, and some mystery.

"Can the steam boats be made safer than they are?" said Harry.

"Since accidents have happened," said the captain, "they may happen again; but many that have will hardly occur again. We shall guard against them in future."

"May I ask, sir," said Harry, very respectfully; "might I ask what was the cause of those accidents, and how you guard against them now?"

"You may ask, and welcome, my eager little man," said the captain, with a good-humoured smile; "but I cannot undertake to answer you all this at once, or at any time. Certainly not now, my dear little fellow," added he, looking at his watch, "for I must be off. So good-bye to you."

THE poor woman with her child stood close to the place where Harry must pass, when he was to land. With a grateful smile, she said to him, as he came near,

“ Master, my child here is a deal the better for that sweet sleep she had ; thanks to you for it.”

Pleased, yet ashamed to have this said to him, in the hearing of several people who were standing by, Harry coloured up to the ears, and answered in a blunt manner, and in a rude tone —

“ Do not thank me for nothing. I did nothing at all.”

The child, running before him so as to stop him, as he would have pushed on, held up her cocoa nut, and said,

“ I will give you this. Take it — do.”

“ Oh no ! I cannot take it from you,” said Harry ; “ but thank you, thank you.”

The child still held up the cocoa nut, and Harry seeing that she looked vexed by his refusal, took it from her hands, and turning back, rolled it along the deck.

"Run after it; run!" said he; "and thank you as much as if I had it. Good bye."

The child ran after the rolling ball, and Harry sprung from the boat on shore. A chaise was procured at Lamplighter's Hall, an inn near the landing place, and his father and he were now to go in it back to Clifton. Harry's head was so full of the steam boat, that he could think and talk of nothing else all the way.

"Father, among other advantages which steam boats have over carriages with horses and men; there is this great one, that the steam engines neither eat, nor drink, nor sleep. And steam never grows tired, but horses and men must rest sometimes."

"I wish you would rest now, Harry, a little," said his father, "and do not kick my shins in your transports."

"I beg your pardon," said Harry. "But, father, I do not see why a steam boat should not go on for weeks and months, just as well as for hours and days."

Surely it can go as long as there is fire, and as long as there is water. Cannot it?"

"Surely; as long as we can supply the engine with fuel, and the boiler with water, and as long as the machinery does not break."

"Then, if they make the whole strong enough," said Harry, "why should not people cross the great ocean from England to America, as well as the little sea from England to Ireland? Why not, father? What is the difficulty? You look as if there were some impossibility."

"No, Harry—not an impossibility; but there is a difficulty, and a great difficulty," said his father; "and if you consider you will perceive what it is."

Harry considered; but he did not find it out. His mind was too much exalted; he was too full of the noble steam boat to be able to think with his usual degree of attention.

His father helped him a little to settle his thoughts, and brought him to consider

the time which would be requisite for this voyage to America.

"It takes about three weeks, Harry. What would be absolutely necessary to the steam boat to enable it to stay out at sea all that time, and to perform its voyage?"

"Fire, water, men—that is all," said Harry, "except provisions; the usual things which are carried for long voyages, we may take for granted, are carried."

"True; but there is something which you have not yet named, that is essential," said his father; "by essential, I mean that without which the thing cannot be."

"Fire, water, men—men, fire, water," repeated Harry. "I can think of nothing else which you could say is essential. I need not say *men* even. One man could regulate the engine I believe."

"What do you mean by regulate the engine?" said his father.

"I mean," said Harry, "he can supply the boiler with water, and the fire with

fuel. Fuel! aye, now I see what you mean, father. Fuel there must be to keep up the fire to boil the water to make the steam. So coals must be carried, or wood, and great quantities; but their weight we need not mind on the water, and with that power of steam, you know, father."

"I know, son; but what will you do about the bulk. Coals, or wood, or whatever fuel be put on board your steam boat, must take up space. Calculate how much."

After going through a calculation, which need not be here repeated, Harry groaned; and acknowledged, that unless the steam boat were many times larger than any that had ever been made, it could not afford space for the necessary quantity of fuel.

"But why," argued he, "should not a vessel be made several times larger than any we have seen?"

A moment's reflection showed him, that such increased bulk would require increased strength to keep it together, and

that again must bring increase of weight, and difficulty of managing the whole.

"Still," said Harry, "though there is this great difficulty about carrying the fuel, we should not give it up, should we, father? Perhaps some of those ingenious men, who first thought of steam boats a hundred years ago, or even fifty years ago, imagined they should never succeed. And they were laughed at, were not they, because they did not succeed at first? Yet now! Oh if they were alive now! and could see what their invention has come to! The admiration of the whole world! Therefore, father, I think people should not mind being laughed at, when they know they are right; and they should not be stopped in their great discoveries by little difficulties, or great difficulties, or any sort of difficulties, but still go on trying experiments, and inventing, till they come to some impossibility, and then they must be quiet. But not till then, they need not give up: and they should not," cried Harry.

"Right, right, my dear boy," said his

father; "I am glad to see this spirit rising in you."

Harry was silent for a mile or two, and then exclaimed —

"Father! I am so glad you have no book this morning to read in the carriage, because you have time to talk to me. Tell me what accidents happened formerly in the steam boats, and how do people prevent them now, as the captain said they can?"

The principal accidents, and the most dangerous," replied his father, "have been the bursting of the boilers. If I recollect rightly, one which burst in an American vessel killed several people, and blew the boat to pieces. Another, which burst in England, scalded to death the persons in the cabin who were near it."

"The sailor spoke truth then," said Harry, "to that poor woman this morning, though I did not believe him. He advised her not to go on board the steam boat, because he said that many such accidents have happened, and happen very often."

"There he was wrong," said Harry's father; "because he exaggerated. But few have occurred. We have accounts of them all, and can therefore judge and speak positively."

"I am glad of it, very, very glad," cried Harry. "Now, father, about the ways of preventing them in future, will you tell me that?"

"First tell me, Harry, do you know the difference between what is called *malleable*, or *wrought iron*, and *cast iron*. You saw both, and the difference was explained to you, when we were at the foundry."

"I recollect it, father," replied Harry. "*Cast iron* is, I believe, that which has been melted and made to run into the form in which it is to be used. *Malleable* or *wrought iron* is that which is hammered, when it is heated, into the shape, whatever it may be, that is required."

"Since you know this much, Harry, I can go on," said his father. "It has been found by many trials, that hammered, or wrought iron, is stronger than cast iron ;

and better able to resist the expansive force of steam. Those boilers of steam engines which burst, were, in almost all instances, made of cast iron. Others of wrought iron have also, in some cases, given way ; but even when they have, they have not exploded violently, so as to do mischief. They have rent asunder, and opened, so as to let out the steam. In consequence of this experience, boilers are now generally made of wrought iron. This is one cause of increased safety."

"And a great one," said Harry.

"Another step in improvement and safety has been made," continued his father, "by experience having proved to us, that though copper is rapidly destroyed by alternate heating and cooling, it is more durable than iron for boilers of steam vessels at sea."

"Copper stronger than iron, father!" cried Harry. "I should never have thought it was."

"You do not repeat with your usual exactness what I told you," said his father.

"I did not assert that copper is in all circumstances, and for all purposes, stronger, and more durable than iron. I said, that it has been found to be more durable when used as the boiler of a steam engine at sea."

"At sea!" repeated Harry. "Father, I know that you have some particular reason for being so careful in the words of what you say, and in that emphasis you laid upon sea."

"Find out my reason then," said his father.

"Perhaps," said Harry, "there may be something in sea water which rusts iron, and so destroys it; and perhaps *that*, whatever it may be, does not rust and destroy copper."

"Just so, Harry. But what is that something? You are acquainted with it," said his father.

"Is it sea salt," said Harry, "which is in the water?"

"Yes, Harry; a chemist has lately tried experiments, which have ascertained this fact; and in consequence of these ex-

periments it has been decided, that in future the boilers should be made of copper."

"How useful it is to try experiments!" said Harry. "That settles what is truth, and there is no more doubting or disputing. That chemist was a sensible man."

"And here is another large instance, Harry," said his father, "in which chemistry has assisted the mechanic."

"True, father," said Harry; "but there is another question I want to ask you, about the paddle wheels. What were the improvements in them, of which those gentlemen were talking?"

"I cannot explain them to you, Harry," said his father; "because you do not know distinctly the difficulties and the faults in the present construction, and these I cannot now describe to you. You should first see them in action in the water."

"And how, and when can I do that?" said Harry.

"Not now, when we are going in a

carriage on land," said his father, laughing; "but some time or other we may be in a boat within view of a steam vessel."

Harry sighing, repeated, "Some time or other. Is there any other great improvement you could explain to me?"

His father yawned, and said he began to be weary of his questions.

"Only one thing more I have to say," said Harry, "and you need not answer. The steam engine I saw this morning in the boat takes up a great deal of room; if it could be made to do as well in a smaller compass, what a great improvement! How comfortable it would be," said Harry.

"True," said his father; "and how comfortable it would be to me, if you would let me rest now."

"Poor father! so I will; thank you. I have quite tired you."

"No, Harry; but I did not sleep well last night. I drank too strong tea or coffee."

His father went to sleep, and Harry sat as still as a mouse, lest he should waken

him. How tea or coffee could keep people awake he did not know ; he pondered long on that subject, but was never the wiser ; he had never yet been kept awake by either. When the carriage stopped, and not till then, his father wakened, quite refreshed.

When they got out their postillion begged Harry to stay a minute, while he fumbled for something in the side pockets, and then in the front pocket of the carriage.

“ It was here. It should be here. They told me it was here,” muttered the postillion, while he continued his search with his legs out, and his body in the chaise : at last in the sword case he found what he had been told was there ; and he brought out the cocoa nut, which he put into Harry’s hands, telling him that a sailor charged him not to forget it. He said that a mother and child sent it to him ; and the message was, that “ it might make him a cup some time or other ; and had good milk in it, if he could get it out.”

The postillion was anxious to deliver this message correctly; for he said he knew the woman, who had been always very kind to him.

Lucy, who had been looking out of the window of the inn, watching for their return, heard what passed, and saw the cocoa nut with joy. She ran to meet Harry, and to learn from him who gave it to him, and to hear an account of his adventures. These he told with all the details she desired, till he came to the moment of the woman's crossing his passage as he left the boat. Then pausing, and turning his cocoa nut about in every direction, he said he was ashamed to tell her how crossly he had spoken.

His father added, "Yes, Harry, you are right to be ashamed; I was ashamed for you."

"I wonder you did not tell me so at the time, father," said Harry.

"I knew it would not do you any good at the moment. I thought you would recollect it afterwards yourself, as I find you

do ; and I hope the pain you now feel will prevent you from doing the same sort of thing again."

"I hope it will," said Harry ; "but when that kind of feeling comes over me, it is so disagreeable I do not know what I am doing or saying. And I am angry with myself, and with the people who speak to me, and with every body. But the pain of reproaching myself afterwards with having been ill-natured is worse still, as I feel now, and I shall remember this, and I will try and conquer myself next time."

"I am sure you will try, and I am sure you will do it," said Lucy.

"Take the cocoa nut," said Harry, putting it into her hands. "We will not open it yet. Pack it up somewhere for me."

"Men always talk of packing up a thing *somewhere*," thought Lucy, "and women are to find where."

It required Lucy's best powers of packing to find *a somewhere* for the cocoa nut ; but she did at last stow it into the carpet

bag, contrary to the prophecies of all beholders.

When they were leaving Bristol, they stopped at a bookseller's to buy some book or books to read in the carriage. Several works were spread upon the counter in the bookseller's shop for them to take their choice. Harry and Lucy read the title pages of some, which their father and mother allowed them to look over.

"We will dip here and there in the books," said Harry, "and see whether they look entertaining. May we, papa?"

"May we cut the leaves," said Lucy, peeping between two uncut pages.

The shopman, with some hesitation, presented an ivory cutter to her, telling her that she was welcome to cut the leaves, if she would be so good as to take care not to tear them. He became at ease when he saw her set about the operation, perceiving she was used to it, and dextrous. But care sat on the bookseller's brow, "considerate," when Harry took up the ivory knife: he thought that he would tear away,

like most other boys that he had seen, without heeding what mischief they did.

"If I make the least *jag*, I will stop, and show it you, sir; you may depend upon that," said Harry, proudly. "You may trust to our honour. Whoever jags first, stops."

"Very well," said their father, looking up from the book he was reading, "upon that condition you may cut away."

They were glad to see their father and mother both caught by some new book, sitting down to read. "We shall have good time," said they, "to cut and dip." After each cutting half a volume, they showed the edges of the books. Not the slightest indenture appeared, that could, by the most exact bookseller's eye, be accounted a *jag*. All was smooth and fair, even to the inmost recess of the dangerous corner of the quadruple page.

"Now we have cut enough," said Lucy; "let us dip three times, Harry, and catch what we may."

Harry seized upon one of the books, and

opened upon this passage, which he read aloud :—

“ As the gloomy habitation my grandfather was in was not to be long endured but from necessity, they were contriving other places of safety for him, particularly one, under a bed which drew out, in a ground floor, in a room of which my mother kept the key. She and the same man worked in the night, making a hole in the earth, after lifting up the boards, which they did by scratching it up with their hands, not to make any noise, till she left not a nail upon her fingers ; she helping the man to carry the earth, as they dug it, in a sheet on his back, out at the window into the garden. He then made a box at his own house, large enough for her father to lie, with bed and bed clothes, and bored holes in the boards for air. When all this was finished, for it was long about, she thought herself the happiest creature alive.”

“ I have heard that before !” cried Lucy. “ The Lady Grisell Baillie. Mamma, I heard you reading it last winter to papa. Oh, mamma ! do you remember the diverting part about the sheep’s head ? I will show it to you, Harry ; lend me the book for one minute. But this is not the same book you had,” continued she ; “ that was a

poem*, and there were notes to it. Here is no poetry! and I am very sorry. I wish I could see again that pretty description of all that Grisell did when she was a young girl. I am sure Harry would like that, though it is poetry."

"Shall I try?" said her mother. "I think I can remember the lines you mean:—

‘ And well, with ready hand and heart,
Each task of toilsome duty taking,
Did one dear inmate take her part,
The last asleep, the earliest waking.
Her hands each nightly couch prepared,
And frugal meal on which they fared;
Unfolding spread the servet white,
And deck’d the board with tankard bright.
Through fretted hose, and garment rent,
Her tiny needle deftly went,
Till hateful penury, so graced,
Was scarcely in their dwelling traced.
With rev’rence to the old she clung,
With sweet affection to the young.
To her was crabbed lesson said,
To her the sly petition made,
To her was told each petty care,
To her was lisp’d the tardy prayer,

* *Metrical Legends*, by Joanna Baillie.

What time the urchin, half undrest,
And half asleep, was put to rest."

"Thank you, mamma. I *do* like it," said Harry.

"I am glad to see there is something new in these 'Memoirs of Grisell Baillie,'" resumed Lucy, who had been looking over the book. "Here is more than we had in the notes to the poem. Pray, mamma, pray buy this book for the carriage."

"No, my dear, I will not buy it for the carriage," said her mother, laughing; "but I will buy it for myself, if you please, and I will read to you whatever can entertain you."

"Thank you, mamma. Harry, are not you glad we are to have this book?" said Lucy. "Hey, Harry?"

But Harry made no answer; he was intent upon a passage in another book, which he had just opened.

"What is it," said Lucy, looking over his shoulder. "Oh, I see the word steam engine, that is enough for him. But now Harry, do not choose a stupid book."

"No danger of that, miss. This is one of the Scotch novels," said the shopman.

"A novel, Harry!" said Lucy; "how did a steam engine get into it?"

"I do not know," said Harry; "but I know that I have found a fine character of—I will not tell you, but you shall hear it. Father, would you be so kind as to read it out to my mother and Lucy?"

"Why should not you be so kind, Harry, as to read it to them yourself?" said his father.

"Because, father, I cannot do justice to it," said Harry; "and it is so good, that I could not bear to spoil it. Pray, father, read it." Here is the book."

His father read the following character of the great inventor of the steam engine:—

"Amidst this company stood Mr. Watt, the man whose genius discovered the means of multiplying our national resources, to a degree, perhaps, even beyond his own stupendous powers of calculation and combination; bringing the treasures of the abyss to the summit of the earth. Giving the feeble arm of man

the momentum of the Afrite — commanding manufactures to arise, as the rod of the prophet produced water in the desert — affording the means of dispensing with that time and tide which wait for no man ; and of sailing without that wind, which defied the commands and threats of Xerxes himself. This potent commander of the elements — this abridger of time and space — this magician, whose cloudy machinery has produced a change in the world, the effects of which, extraordinary as they are, perhaps are only now beginning to be felt, was not only the most refined man of science, the most successful combiner of powers, and calculator of numbers, as adapted to practical purposes ; was not only one of the most generally well informed, but one of the best and kindest of human beings.’ ”

Several gentlemen, who had been reading, laid down their books to listen to this eloquent and just eulogium. When it was finished, and when the reader's voice stopped, there was silence for a moment — then a general burst of admiration.

“ Who wrote it ? Where is it ? Whose is it ? ”

All crowded round Harry to look at the book. Harry felt proud of having found out *for* himself, and *by* himself, what was

good. It is scarcely necessary to say that his father bought the work. The parcel was made up, put into the carriage, and they drove on. As soon as they were out of the noisy streets, Harry and Lucy seized again upon this book, eager to know if there was any thing more in it about Mr. Watt. They found an account of his powers of pleasing in conversation, and of his great variety of knowledge.

This struck Harry with fresh admiration.

"How I wish papa had known him!" cried Lucy. "Oh, Harry! if you had but seen him! Should not you have liked it very much?"

"I should not have cared for merely seeing him," said Harry, "unless I could have heard him and known him."

They now began to question each other, which of all the great people, of whom they had ever heard or read, they should most wish to have seen and known? And then, which they should have liked only *just to see*? which to have for acquaint-

ance? which for friends? and which they should like to live with always?

These questions brought on a great deal of interesting and diverting discussion, during which papa and mamma were often appealed to, and in which they took their share, much to Harry and Lucy's delight. The number of those with whom they should choose to live, which at first was prodigious, on Lucy's part especially, was gradually reduced, till at last it came down to very few indeed — not above five or six.

It was observed, that Harry, who, in former times, desired to see only great mechanics, now desired to know great chemists too, and all sorts of sensible and *inventing* people, as he said.

This was one good consequence, as Lucy remarked, of their having lately travelled so much. "But to-morrow, Harry," continued she, "is to be the last day's travelling. Are you glad or sorry, Harry? I do not know which I am myself; partly glad, partly sorry I feel. Sorry that the journey

will be at an end, because I like travelling very much, and seeing every day some new and entertaining things and people. But I shall be glad for one great reason to come to the end of our journey, that we may see the cottage by the sea-side. I long to know what sort of a looking cottage it is. Do not you, Harry?"

"Yes," said Harry; "but above all I wish to see the ocean."

"And the sea shore," cried Lucy, "where I may pick up hundreds of shells!"

"And I hope I shall see ships!" said Harry.

"And a boat with sails, in which we may sail sometimes," said Lucy.

"Yes, I should like that very much," said Harry. "I want to know more about sails."

"Shoulder of mutton sails especially," cried Lucy; "which I remember reading about in Robinson Crusoe. I wonder what they are?"

Her father sketched for her a shoulder of mutton sail, and she was rather disappointed when she learned, that the name arose merely from the shape.

The conversation was interrupted by the sight of a boat on a river; but it had no sails—it was a ferry boat.

At Harry and Lucy's age it was a real pleasure to cross a ferry, though to travellers, more advanced in years, it may sometimes be a pain, or at least a trouble. They are apt to prefer a bridge.

NOTE TO PAGE 314,

On Steam Engines.

*Extract of a Letter to the Author, from a
scientific Friend.*

“ In estimating the power of steam engines and in steam boats, it would be much more in congruity with powers formerly used, and more magnificent in appearance, if the comparison were made with men rather than with horses. Thus a steam vessel, furnished with two engines, each of fifty horse power, might be stated to have the continual force of fourteen hundred rowers.

“ I may add, on the subject of steam engines, that we have several working in Cornwall with cylinders ninety inches (7ft. 6in.) in diameter, and ten feet clear way for the piston. These dimensions, with steam producing an actual power of ten pounds to the inch, give an effect of 636,170 pounds one foot high, which is about half of a good day's work for a strong man. I am not sure whether either of these engines work double; that is, condenses above as well as below the pistons: there cannot be any reason against their being so worked, and they cer-

tainly might make ten double strokes in a minute. Their effect then in 24 hours, $24 \times 60 \times 10 \times 2 \times 636171$ ($= \frac{1}{2}$ a day's work), would be equal to the work of fourteen thousand four hundred (14,400) men; and as one horse is equal to about fourteen men, the engine would equal the work of a thousand horses."



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